

## Mobile Access Gateway (MAG) Multipath Options

### Abstract

This specification defines extensions to the Proxy Mobile IPv6 (PMIPv6) protocol that allow a mobile access gateway (MAG) to register more than one proxy care-of address (pCoA) with the local mobility anchor (LMA) and to simultaneously establish multiple IP tunnels with the LMA. This capability allows the MAG to utilize all the available access networks to route the mobile node's IP traffic. This document defines the following two new mobility header options: the MAG Multipath Binding option and the MAG Identifier option.

### Status of This Memo

This is an Internet Standards Track document.

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## 1. Introduction

Multihoming support on IP hosts can greatly improve the user experience. With the simultaneous use of multiple access networks, multihoming brings better network connectivity, reliability, and improved quality of communication. The following are some of the goals and benefits of multihoming support:

- o Redundancy/Fault-Recovery
- o Load balancing
- o Load sharing
- o Preference settings

According to [RFC4908], users of small-scale networks can benefit from a mobile and fixed multihomed architecture using mobile IP [RFC6275] and Network Mobility (NEMO) [RFC3963].

The motivation for this work is to extend the PMIPv6 protocol with multihoming extensions [RFC4908] for realizing the following capabilities:

- o Using GRE as mobile tunneling, possibly with its key extension [RFC5845].
- o Using UDP encapsulation [RFC5844] in order to support NAT traversal in an IPv4 networking environment.
- o Using the 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), which allows the appropriate traffic-steering decisions to be made.

PMIPv6 relies on two mobility entities: the MAG, which acts as the default gateway for the end node (either a mobile or a fixed node) attached to the MAG's access links, and the LMA, which acts as the topological anchor point. IP tunnel is created with any one of the supported encapsulation mode between the MAG and the LMA. Then, the MAG and LMA distribute the end node's traffic over these tunnels. All PMIPv6 operations are performed on behalf of the end node and its correspondent node. Thus, it makes PMIPv6 well adapted to multihomed architecture as considered in [RFC4908]. Taking the LTE and WLAN networking environments as examples, the PMIPv6-based multihomed architecture is depicted in Figure 1. In this example, IP flows,

Flow-1 and Flow-3 are routed over Tunnel-1 and Flow-2 is routed over Tunnel-2. However, IP traffic belonging to Flow-4 is distributed on both Tunnel-1 and Tunnel-2 paths.

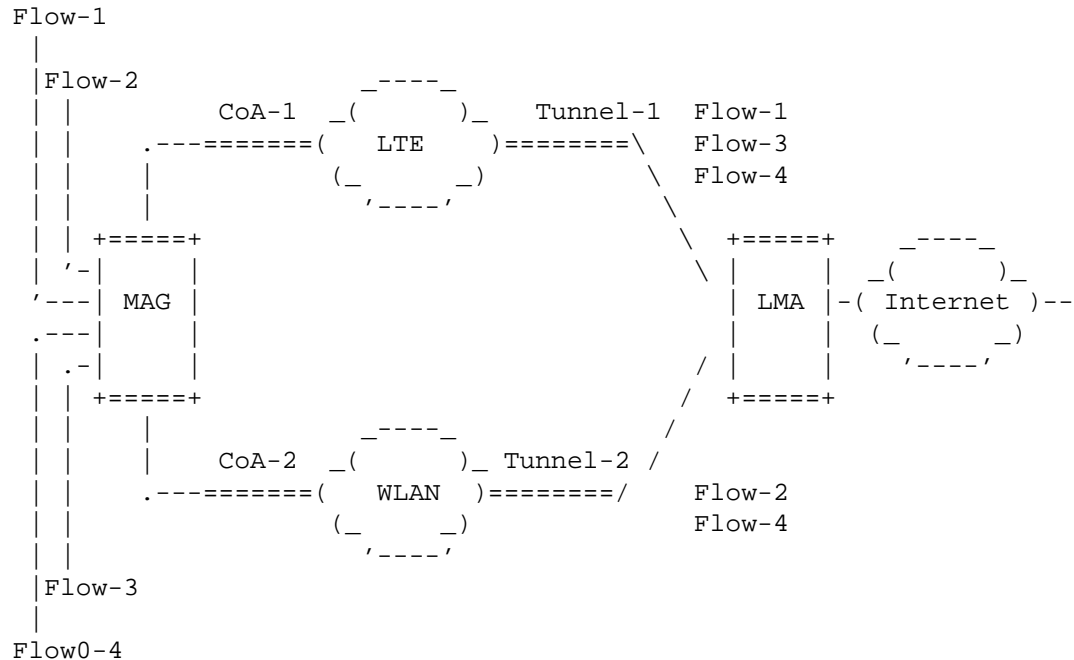


Figure 1: Multihomed MAG Using Proxy Mobile IPv6

The current version of PMIPv6 does not allow a MAG to register more than one pCoA 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 pCoAs extension for PMIPv6.

## 2. Conventions and Terminology

### 2.1. Conventions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

## 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 term:

IP-in-IP

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

## 3. Overview

### 3.1. Example Call Flow

Figure 2 is the call flow 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 call flow are as follows:

Steps (1) and (2): The MAG attaches to both WLAN and LTE networks. Then, the MAG obtains two different pCoAs, respectfully.

Step (3): The MAG sends, over the LTE access, a Proxy Binding Update (PBU) message with the new MAG Multipath Binding (MMB) and MAG Network Access Identifier (MAG-NAI) options to the LMA. The request can be for a physical mobile node attached to the MAG or for a logical mobile node configured on the mobile access gateway. A logical mobile node is a logical representation of a mobile node in the form of a configuration that is always enabled on the MAG. The mobility session that is created (i.e., create a Binding Cache Entry (BCE)) on the LMA will be marked with multipath support.

Step (4): The LMA sends back a Proxy Binding Acknowledgement (PBA) including the Home Network Prefix (HNP) and other session parameters allocated for that mobility session.

Step (5): IP tunnel is created between the MAG and the LMA over LTE access with any one of the supported encapsulation modes.

Steps (6) to (8): The MAG repeats steps (3) to (5) on the WLAN access. The MAG includes the HNP, received on step (4) in the PBU. The LMA updates 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 to the MAG by the LMA.

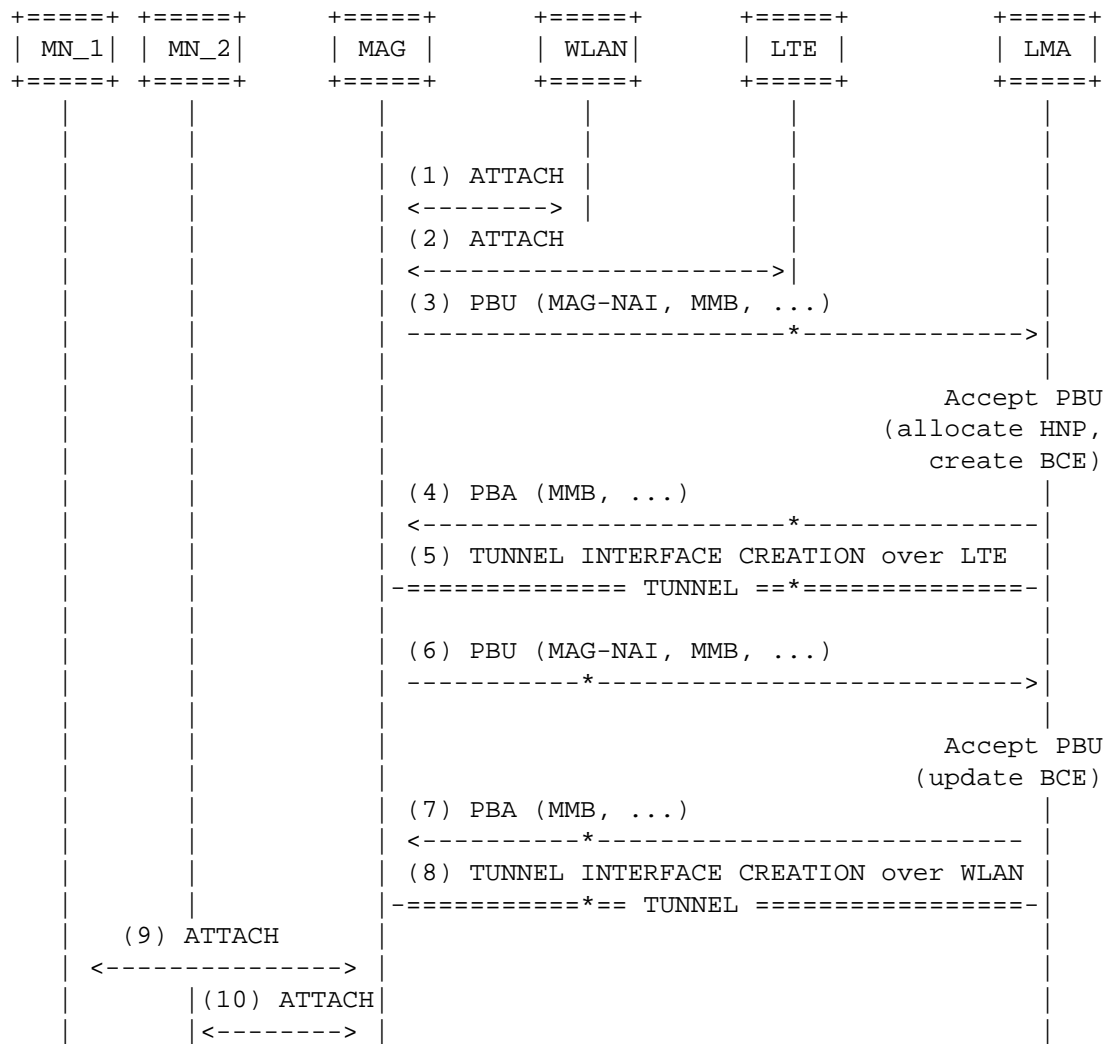


Figure 2: Functional Separation of the Control and User Planes

### 3.2. Traffic Distribution Schemes

When the MAG has registered a multipath binding with the LMA, there will be multiple established overlay tunnels between them. The MAG and the LMA can use any one, or more, of the available tunnel paths for routing the mobile node's IP traffic. This specification does not recommend or define any specific traffic distribution scheme. However, it identifies two well-known approaches that implementations can potentially use. These approaches are per-flow and per-packet traffic distribution schemes.

#### Per-Flow Traffic Distribution:

- o In this approach, the MAG and the LMA associate each of the IP flows (upstream and downstream) with a specific tunnel path. The packets in a given IP flow are always routed on the same overlay tunnel path; they are never split and routed concurrently on more than one tunnel path. It is possible for a given flow to be moved from one tunnel path to another, but the flow is never split. The decision to bind a given IP flow to a specific tunnel path is based on the traffic distribution policy. This traffic distribution policy is either statically configured on both the MAG and the LMA or dynamically negotiated over PMIPv6 signaling. The Flow Binding extension [RFC6089] and Traffic Selectors for Flow Bindings [RFC6088] define the mechanism and the semantics for exchanging the traffic policy between two tunnel peers; the same mechanism and the mobility options are used here.

#### Per-Packet Traffic Distribution:

- o In this approach, packets belonging to a given IP flow will be split and routed across more than one tunnel path. The exact approach for traffic distribution or the distribution weights is outside the scope of this specification. In a very simplistic approach, assuming that the established tunnel paths have symmetric characteristics, the packets can be equally distributed on all the available tunnel paths. In a different scenario, when the links have different speeds, the chosen approach can be based on weighted distribution (e.g., n:m ratio). However, in any of these chosen approaches, implementations have to be sensitive to issues related to asymmetric link characteristics and the resulting issues such as reordering, buffering, and the impact on application performance. Care must be taken to ensure that there is no negative impact on the application performance due to the use of this approach.

## 4. Protocol Extensions

### 4.1. MAG Multipath Binding Option

The MAG Multipath Binding option is a new mobility header option defined for use with PBU and PBA messages exchanged between the LMA and the MAG.

This mobility header option is used for requesting multipath support. It indicates that the MAG is requesting that the LMA register the current CoA associated with the request as one of the many CoAs

through which the MAG can be reached. It is also used for carrying the information related to the access network associated with the CoA.

The MAG Multipath Binding option does not have any alignment requirement. Its format is as shown in Figure 3:

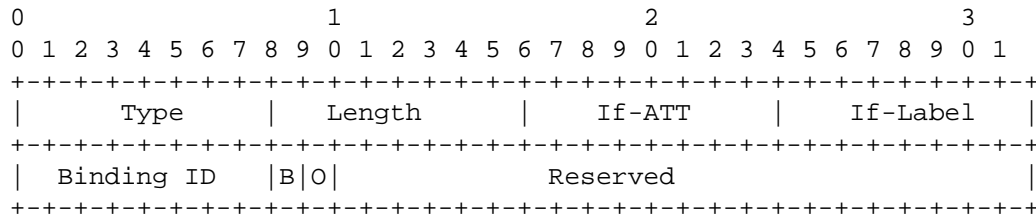


Figure 3: MAG Multipath Binding Option

#### Type

Type: MAG Multipath Binding (63)

#### 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 <<https://www.iana.org/assignments/mobility-parameters/>> defined in [RFC5213].

#### Interface Label (If-Label)

This 8-bit unsigned integer represents the interface label.

The interface label is an identifier configured on the WAN interface of the MAG. All the WAN interfaces of the MAG that are used for sending PBU messages are configured with a label. The labels merely identify the type of WAN interface and are primarily used in application-routing policies. For example, a Wi-Fi interface can be configured with a label "9" and an LTE interface with a label "11". Furthermore, the same label may be configured on two WAN interfaces of similar characteristics (e.g., two Ethernet interfaces with the same label).



Interface labels are signaled from the MAG to the LMA in the PBU messages and both the LMA and MAG will be able to mark each of the dynamically created Binding/Tunnel with the associated label. These labels are used in generating consistent application-routing rules on the both the LMA and the MAG. For example, there can be a policy requiring HTTP packets to be routed over an interface that has the interface label of "9", and if any of the interfaces with interface label "9" are not available, the traffic needs to be routed over the interface with the interface label "11". The MAG and the LMA will be able to apply this routing rule with the exchange of interface labels in PBU messages and by associating the application flows to tunnels with the matching interface labels.

#### Binding Identifier (BID)

This 8-bit unsigned integer is used for identifying the binding. The permitted values are 1 through 254. The values 0 and 255 are reserved.

The MAG identifies each of the mobile node's bindings with a unique identifier. The MAG includes the identifier in the PBU message; when the PBU request is accepted by the LMA, the resulting binding is associated with this BID in the mobile node's Binding Cache entry.

#### Bulk Re-registration Flag (B)

If set to a value of (1), this flag notifies the LMA to consider this as a request to update the binding lifetime of all the mobile node's bindings upon accepting this specific request. The (B) flag MUST NOT be set to a value of (1) if the value of the Registration Overwrite (O) flag is set to a value of (1).

#### Registration Overwrite (O)

This flag, if set to a value of (1), notifies the LMA 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 PBU and PBA messages exchanged between the LMA and the MAG. This mobility header option is used for conveying the MAG's identity.

This option does not have any alignment requirements.

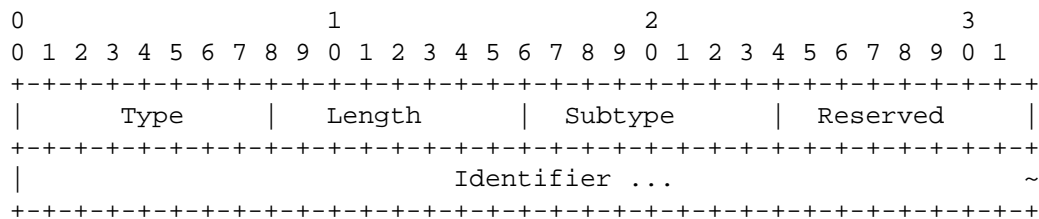


Figure 4: MAG Identifier Option

### Type

Type: MAG Identifier (64)

### 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 <<https://www.iana.org/assignments/mobility-parameters/>>.

### 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 the 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 PBA messages.

The LMA SHOULD use this error code when rejecting a PBU message from a MAG requesting a multipath binding. The following is the potential reason for rejecting the request:

- o The LMA does not support multipath binding.

CANNOT\_SUPPORT\_MULTIPATH\_BINDING (Cannot Support Multipath Binding):  
180

#### 4.4. Signaling Considerations

- o The MAG, when requesting multipath support, MUST include the MAG Multipath Binding option ([Section 4.1](#)) in each of the PBU messages that it sends through the different WAN interfaces. The inclusion of this option serves as a hint that the MAG is requesting multipath support. Furthermore, the MAG Identifier option MUST also be present in the PBU message.
- o If the MAG is aware that the LMA supports the multipath binding option defined in this specification and if it chooses to use multiple paths, then it can send the PBU packets for each of the paths, either sequentially or concurrently. However, if the MAG is not aware of the LMA capability, then it SHOULD first discover the LMA capability by sending PBU packets with multipath on only one path first. This will ensure that the LMA will not be overwriting the binding of one path with the other path.
- o If the LMA supports multipath capability as defined in this specification and if it enables the same for a mobile node's session per the MAG's request, then the LMA MUST include the Multipath Binding option ([Section 4.1](#)) without the MAG-NAI option ([Section 4.2](#)) in the corresponding PBA reply.
- o If the LMA is a legacy LMA that does not support this specification, the LMA will skip the MAG Multipath Binding option (and MAG-NAI option) and process the rest of the message as specified in the base PMIPv6 specification ([\[RFC5213\]](#)). Furthermore, the LMA will not include the MAG Multipath Binding option (or the MAG-NAI option) in the PBA message. The MAG, upon receiving the PBA message without the MAG Multipath Binding option, SHOULD disable multipath support for the mobile node.

- o If the mobile node is not authorized for multipath support, then the LMA will reject the request by sending a PBA message with the Status field value set to CANNOT\_SUPPORT\_MULTIPATH\_BINDING (Section 4.3). The LMA MUST echo the MAG Multipath Binding option (without the MAG-NAI option) in the PBA message. The MAG, upon receiving this message, SHOULD disable multipath support for the mobile node.

## 5. IANA Considerations

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 63 has been allocated for this mobility option from the "Mobility Options" registry at <http://www.iana.org/assignments/mobility-parameters>.

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 64 has been allocated for this mobility option from the "Mobility Options" registry at <http://www.iana.org/assignments/mobility-parameters>.

This document defines a new status value: CANNOT\_SUPPORT\_MULTIPATH\_BINDING (180) for use in PBA messages, as described in Section 4.3. This value has been assigned from the "Status Codes" registry at <http://www.iana.org/assignments/mobility-parameters>.

## 6. Security Considerations

This specification allows a MAG to establish multiple PMIPv6 tunnels with an LMA 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 based on the negotiated flow policy. This new capability has no impact on the protocol security. Furthermore, this specification defines two new mobility header options: the 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 the PMIPv6 Protocol and does not introduce any new security vulnerabilities.

## 7. References

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