

NETEXT WG  
Internet-Draft  
Intended status: Standards Track  
Expires: November 17, 2013

X. Zhou  
ZTE Corporation  
J. Korhonen  
Nokia Siemens Networks  
C. Williams  
Consultant  
S. Gundavelli  
Cisco  
CJ. Bernardos  
UC3M  
May 16, 2013

**Prefix Delegation Support for Proxy Mobile IPv6  
draft-ietf-netext-pd-pmip-07**

**Abstract**

Proxy Mobile IPv6 enables IP mobility for a host without requiring its participation in any mobility signaling, being the network responsible for managing IP mobility on behalf of the host. However, Proxy Mobile IPv6 does not support assigning a prefix to a router and managing its IP mobility. This document specifies extensions to Proxy Mobile IPv6 protocol for supporting network mobility using DHCPv6-based Prefix Delegation.

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## **1. Introduction**

Proxy Mobile IPv6 [[RFC5213](#)] enables network-based mobility management support for an IP host without requiring its participation in any IP mobility signaling. The mobility elements in the network allow an IP host to obtain an IPv4 address and/or a set of IPv6 addresses and be able to obtain IP mobility support for those IP addresses within the Proxy Mobile IPv6 domain. In this context, the mobility management support that is enabled is for an individual IP host, which is the mobile node. The IPv4 home address, or the IPv6 home network prefixes are logically bound to the link shared between the mobile access gateway and the mobile node and only the mobile node can use those IP address by configuring them on the interface attached to that link. Currently, there is no mobility support in Proxy Mobile IPv6 for a mobile router with a mobile network attached to it.

This specification defines extensions to Proxy Mobile IPv6 protocol for allowing mobility support to the mobile networks attached to a mobile router. The mobile router can request the mobility entities in the Proxy Mobile IPv6 domain for one or more delegated IP prefixes using DHCP Prefix Delegation extensions [[RFC3633](#)], or through other mechanisms outside the scope of this document. The mobility entities in the network will provide network-based mobility management support for those delegated prefixes just as how mobility is supported for an home address. The delegated prefixes are hosted in the mobile network attached to the mobile router. IP mobility is ensured for all the IP nodes in the mobile network, even as the mobile router performs an handoff by changing its point of network attachment within the Proxy Mobile IPv6 domain. The local mobility anchor in the Proxy Mobile IPv6 domain will not track the individual IP sessions for all the IP nodes in the mobile network, it only tracks a single mobile router session that is hosting the mobile network.



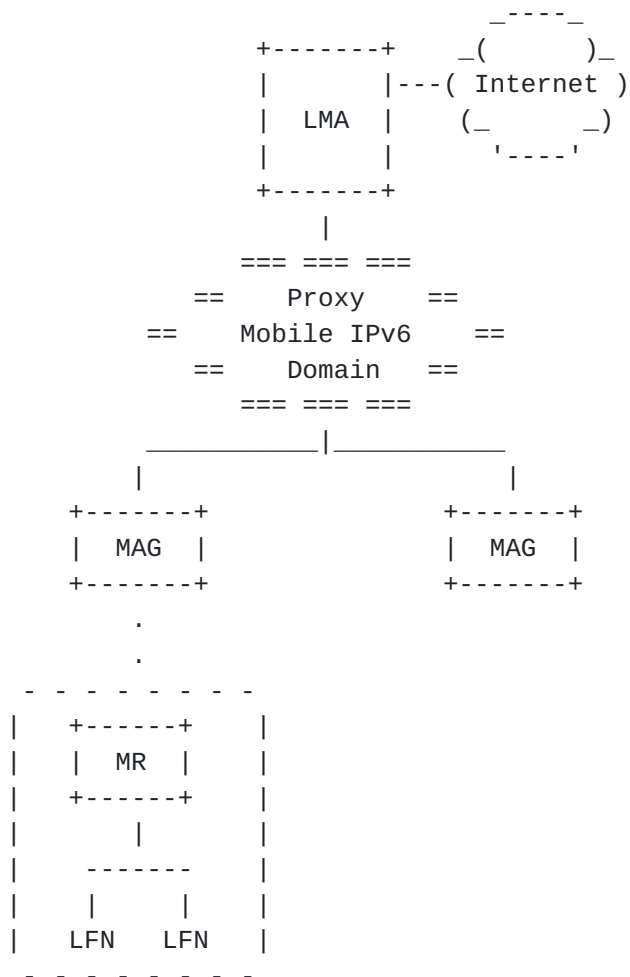


Figure 1: Mobile Router in Proxy Mobile IPv6 Domain

Within the context of this document, the definition of a mobile router extends that of a mobile node definition from [\[RFC5213\]](#), by adding routing capability for routing IP packets between its egress interface (interface used for attachment to the mobile access gateway) and any of its ingress interfaces (interface used for attachment to the mobile network). The network of nodes part of the mobile network are referred to as locally fixed nodes (LFN) and they all move with the mobile router as a single cluster. Figure-1 illustrates a mobile router in a Proxy Mobile IPv6 domain.

Rest of the document identifies the protocol extensions and the operational details of the local mobility anchor and mobile access gateway for supporting this specification.



## 2. Convention and 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 [\[RFC2119\]](#).

All the mobility related terms used in this document are to be interpreted as defined in Proxy Mobile IPv6 specifications [\[RFC5213\]](#) and [\[RFC5844\]](#). All the DHCP related terms are to be interpreted as defined in DHCPv6-PD for NEMO [\[RFC6276\]](#), DHCPv6-PD [\[RFC3633\]](#) and Subnet Allocation Option for DHCPv4 [\[RFC6656\]](#). This document also provides a context-specific explanation to the following terms used in this document.

### Mobile Router (MR)

The term mobile router is used to refer to an IP router whose mobility is managed by the network while being attached to a Proxy Mobile IPv6 domain. The mobile router is a mobile node as defined in [\[RFC5213\]](#), but with additional capabilities for supporting an attached mobile network. The mobility entities in the Proxy Mobile IPv6 domain provide mobility for the IPv4/IPv6 address(es) assigned to the mobile node's egress link and also mobility support to the network prefixes hosted in the network attached to the mobile router.

### Mobile Network

Its an IP network attached to a mobile router. There can be many IP nodes in this IP network. The mobile router is a gateway for these IP nodes for reaching other IP networks or the internet. The mobile router and the attached IP networks move as a single cluster.

### Delegated Mobile Network Prefix (DMNP)

The Delegated Mobile Network Prefix is an IPv4/IPv6 prefix delegated to a mobile router and is hosted in the mobile network. The IP nodes in the mobile network will be able to obtain IP address configuration from the delegated mobile network prefix and will have IP mobility support for that address configuration. The DMNP is topologically anchored on the local mobility anchor and the mobility elements in the Proxy Mobile IPv6 domain provide IP mobility support for the prefix, by forwarding the mobile network traffic to the mobile router.

### Locally Fixed Node (LFN)





Locally Fixed Node is an IP node in the mobile network.

### **3. Solution Overview**

#### **3.1. Stated Assumptions**

- o The mobile router is a mobile node as defined in [[RFC5213](#)], but with additional capabilities for routing IP packets between its egress interface (interface used for attachment to the mobile access gateway) and any of its ingress interfaces (interface used for attachment to the mobile network).
- o The specification assumes that a mobile router is an IPv4/IPv6 router without any capability for mobility management.
- o The mobile router can obtain the delegated IPv4/IPv6 prefix from the network based on the DHCPv6 Prefix Delegation approaches specified in [[RFC3633](#)], or using approaches beyond the scope of this document (Example: Static Configuration). Furthermore, when the mobile router uses DHCPv6-based Prefix Delegation, it will be able to support Prefix Exclude Option for DHCPv6-PD as described in [[RFC6603](#)].
- o The mobile router after its attachment to the network obtains an IPv6 address from its home network prefix (HNP) on its egress interface facing the MAG. This is as specified in [[RFC5213](#)] and [[RFC5844](#)]. Subsequently, the DHCPv6-PD procedures get activated for obtaining the delegated IPv6/IPv4 prefixes for its ingress networks.
- o The mobile router using the DHCP Prefix Delegation approaches specified in [[RFC3633](#)] and [[RFC6656](#)] will obtain the delegated IPv4/IPv6 prefix from the network. The mobile router forwards outgoing packets from its mobile network to the mobile access gateway (MAG), and the MAG delivers the incoming packets to the mobile network through the MR.
- o The mobile router must have obtained an IPv6 address from its home network prefix (HNP) before initiating DHCPv6-PD procedures for obtaining delegated IPv4 or IPv6 prefixes for its ingress networks. This IPv6 address is on the interface attached to the MN-MAG access link as specified in [[RFC3633](#)].

#### **3.2. Deployment Models**

This specification supports the following two two deployment models. The high-level message call flows between the mobile router, mobile access gateway and the local mobility anchor is also presented.



**3.2.1. Delegating Router Co-located with Mobile Access Gateway**

- o The delegating router (DR) function, as specified in [RFC3633], is co-located with the mobile access gateway.
- o The requesting router (RR) function, as specified in [RFC3633], is enabled on the mobile router.

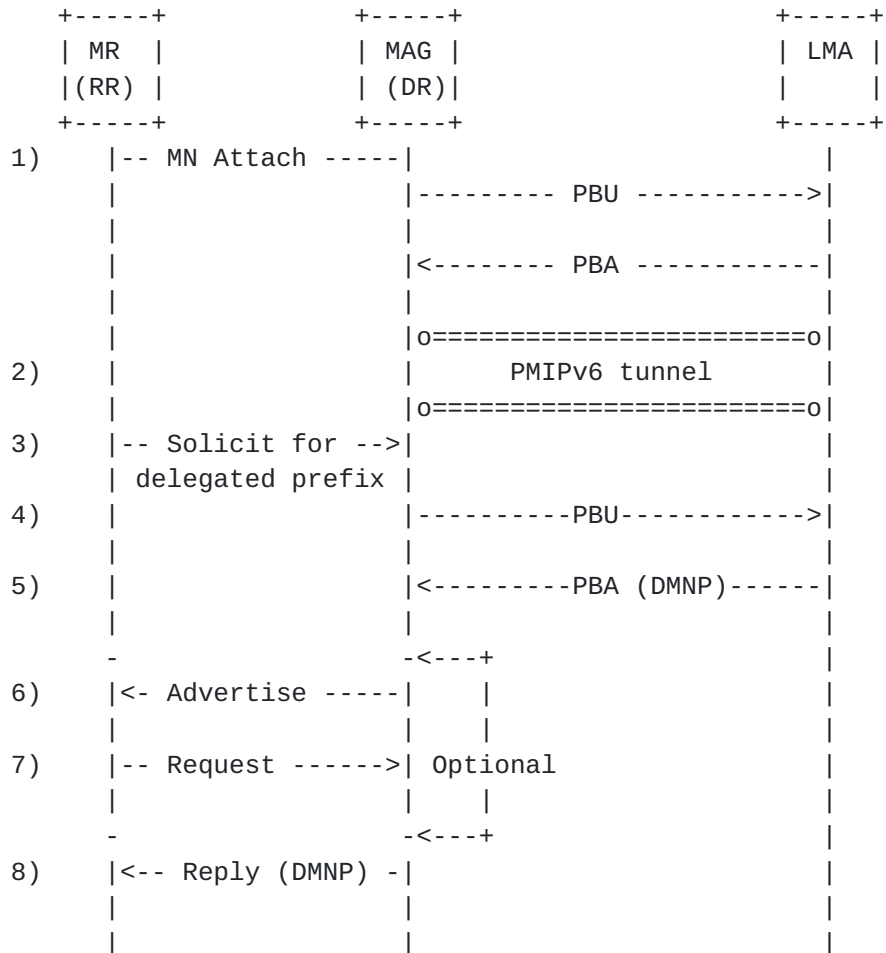


Figure 2: Delegating Router Co-located with Mobile Access Gateway

**3.2.2. Delegating Router Co-located with Local Mobility Anchor**

- o The delegating router (DR) function, as specified in [RFC3633], is co-located with the local mobility anchor.
- o A DHCPv6 Relay Agent (DRA) function, as specified in [RFC3315], is co-located on the mobile access gateway.



- o The requesting router (RR) function, as specified in [[RFC3633](#)], is enabled on the mobile router.

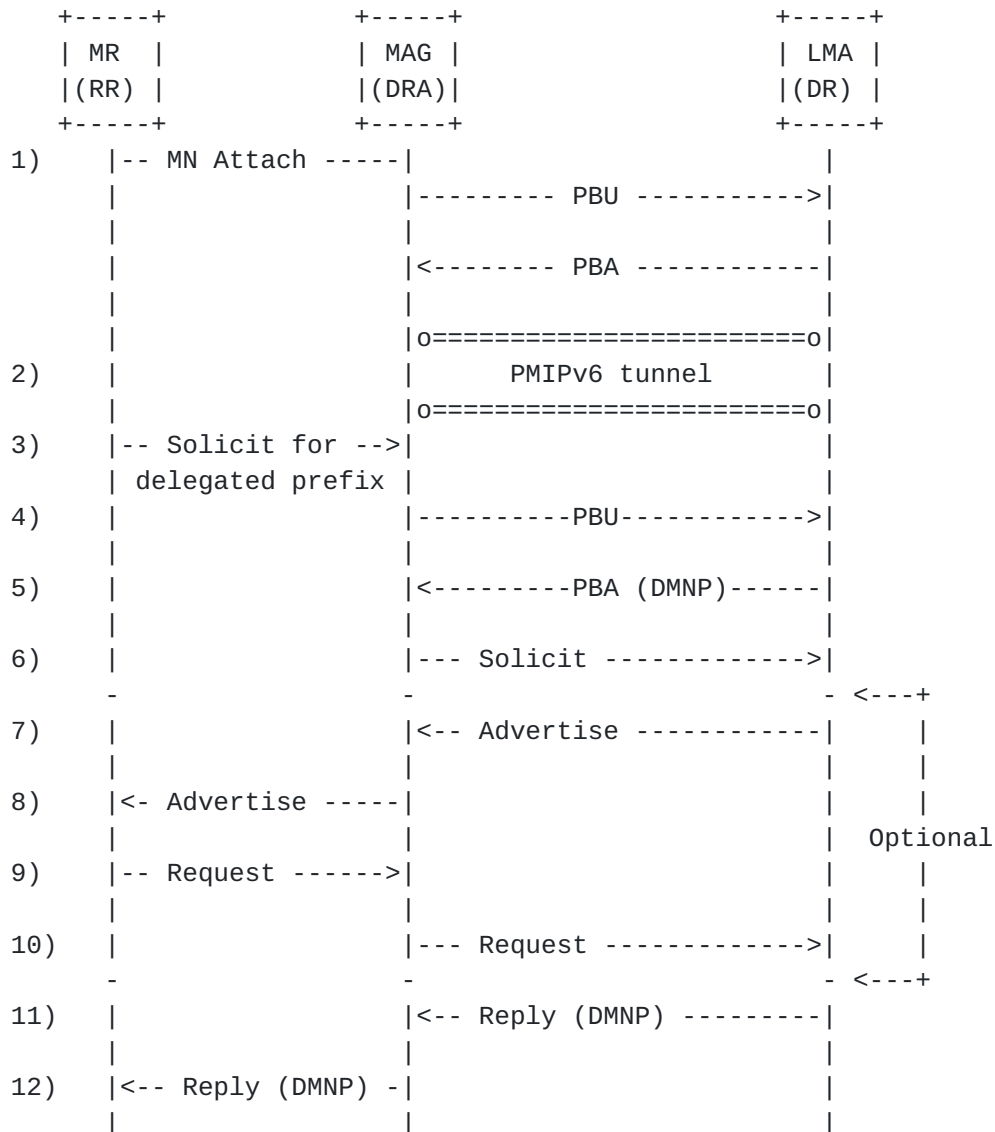


Figure 3: Delegating Router Co-located with Local Mobility Anchor





#### 4. Message formats

This section defines extensions to Proxy Mobile IPv6 [[RFC5213](#)] protocol messages.

#### **4.1. Delegated Mobile Network Prefix Option**

A new mobility header option, Delegated Mobile Network Prefix option is defined for use with Proxy Binding Update and Proxy Binding Acknowledgment messages exchanged between a local mobility anchor and a mobile access gateway. This option is used for exchanging the mobile router's IPv4/IPv6 delegated mobile network prefix. There can be multiple instances of the Delegated Mobile Network Prefix option present in a message.

The Delegated Mobile Network Prefix option has an alignment requirement of  $8n+2$ . Its format is as follows:

[illegible]

Type

To be assigned by IANA.

Length

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

IPv4 Prefix (V)

If the IPv4 Prefix (V) flag is set to a value of (1), then it indicates that the prefix that is included in the DMNP field is an IPv4 prefix. If the IPv4 Prefix (V) flag is set to a value of



(0), then it indicates that the prefix that is included in the DMNP field is an IPv6 prefix.

#### Reserved

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

#### Prefix Length

8-bit unsigned integer indicating the prefix length of the prefix contained in the option.

#### Delegated Mobile Network Prefix

Contains a mobile router's 4-byte IPv4 or a 16-byte IPv6 Delegated Mobile Network Prefix.

### **4.2. Status Codes**

This document defines the following new status code values for use in the Proxy Binding Acknowledgement message. These values have been allocated from the same number space as defined in [Section 6.1.8 of \[RFC6275\]](#).

NOT\_AUTHORIZED\_FOR\_DELEGATED\_MNP: <IANA-2>

Not Authorized for delegated mobile network prefix

REQUESTED\_DMNP\_IN\_USE: <IANA-3>

Requested delegated mobile network prefix is in use



## **5. Operational Details**

### **5.1. MAG Considerations**

#### **5.1.1. Extension to Binding Update List Entry Data Structure**

In order to support this specification, the conceptual Binding Update List Entry (BULE) data structure [RFC5213] needs to be extended to include delegated mobile network prefix (DMNP) list. Each entry in the list is used for storing an IPv4/IPv6 mobile network prefix delegated to the mobile router.

#### **5.1.2. Signaling Considerations**

- o The mobile node's policy profile defined in [RFC5213] is extended to include a parameter which indicates Delegated Prefix support. During the mobile router's initial attachment procedure, the mobile access gateway obtains the mobile router's policy profile, as per the procedures defined in [RFC5213]. If the policy profile indicates that the mobile router is authorized for Delegated Prefix support, then the following considerations apply.
- o For requesting the local mobility anchor to allocate delegated mobile network prefix(es) for the mobile router, the mobile access gateway MUST include one or more Delegated Mobile Network Prefix (DMNP) options in the Proxy Binding Update message.
  - \* There MUST be exactly one instance of the Delegated Mobile Network Prefix option with ALL\_ZERO value and with the (V) flag set to a value of (0). This serves as a request to the local mobility anchor to allocate a set of delegated IPv6 mobile network prefixes.
  - \* There MUST be exactly one instance of the Delegated Mobile Network Prefix option with ALL\_ZERO value and with the (V) flag set to a value of (1). This serves as a request to the local mobility anchor to allocate a set of delegated IPv4 mobile network prefixes.
  - \* There MUST be exactly one instance of the Delegated Mobile Network Prefix option with NON\_ZERO prefix value for each of the mobile network prefixes that the mobile access gateway is requesting the local mobility anchor to allocate. The prefix value in the option is the prefix that is either statically configured for that mobile router, or obtained via DHCP prefix delegation. This serves as a request to the local mobility anchor to allocate the requested IPv4/IPv6 prefix.



- o If the received Proxy Binding Acknowledgement message has the status field value set to NOT\_AUTHORIZED\_FOR\_DELEGATED\_MNP (Not Authorized for delegated mobile network prefix), the mobile access gateway MUST NOT enable mobility support for any of the prefixes in the mobile network and prefix delegation support has to be disabled.
- o If the received Proxy Binding Acknowledgement message has the status field value set to REQUESTED\_DMNP\_IN\_USE (Requested delegated mobile network prefix is in use), the mobile access gateway MUST NOT enable mobility support for the requested prefixes. The mobile access gateway MAY choose to send Proxy Binding Acknowledgement message requesting the local mobility anchor to perform the prefix assignment.
- o If the received Proxy Binding Acknowledgement message has the status field value set to 0 (Proxy Binding Update accepted), the mobile access gateway has to apply the following considerations.
  - \* The delegated mobile network prefix (DMNP) list in the mobile router's Binding Update List entry has to be updated with the allocated prefix(es). However, if the received message was in response to a de-registration request with a lifetime value of (0), then the delegated mobile network prefix list has to be removed along with the Binding Update List entry.
  - \* The mobile access gateway has to set up a policy-based route for forwarding the IP packets received from the mobile network (with the source IP address from any of the delegated IPv4/IPv6 mobile network prefixes) through the bidirectional tunnel set up for that mobile router. However, if the received message was in response to a de-registration request with a lifetime value of (0), then the created forwarding state has to be removed.

#### **5.1.2.1. DHCP - MAG Interactions**

- o The mobile router, acting as a "Requesting Router" as described in [\[RFC3633\]](#), sends a SOLICIT message including one or more IA\_PD option(s) to the Delegating Router collocated on the mobile access gateway. This message provides the needed trigger for the mobile access gateway for requesting the local mobility anchor to enable delegated mobile network prefix support for that mobility session.
- \* The mobile access gateway MUST apply the considerations in ([Section 5.1.2](#)) for requesting the local mobility anchor to enable delegated prefix support.





- \* The mobile access gateway upon completing the Proxy Binding Update signaling with the local mobility anchor will provide the obtained prefixes to the DHCPv6 Delegating Router for prefix assignment.
  - \* The standard DHCPv6 considerations apply with respect to the interactions between the Delegating Router and the Requesting Router.
  - \* Any time the Requesting Router releases the delegated prefixes, the Delegating Router removes the assigned prefixes and the mobile access gateway sends an Updated Proxy Binding Update with the considerations in ([Section 5.1.2](#)) for deregistering those prefixes.
- o The mobile router, acting as a "Requesting Router" as described in [[RFC3633](#)], sends a SOLICIT message including one or more IA\_PD option(s) to the Relay Agent collocated on the mobile access gateway. This message provides the needed trigger for the mobile access gateway for requesting the local mobility anchor to enable delegated mobile network prefix support for that mobility session.
- \* The mobile access gateway forwards the DHCP messages to the local mobility anchor which has the collocated Delegating Router function. The Requesting Router and the Delegating Router complete the DHCP messages related to prefix delegation.
  - \* The standard DHCPv6 considerations apply with respect to the interactions between the Delegating Router, Relay Agent and the Requesting Router.
  - \* The mobile access gateway MUST apply the considerations in ([Section 5.1.2](#)) for requesting the local mobility anchor to enable delegated prefix support. The prefixes that the Delegating Router allocated to the mobile router will be included in the Proxy Binding Update signaling.
  - \* The mobile access gateway upon completing the Proxy Binding Update signaling with the local mobility anchor will provide the obtained prefixes to the DHCPv6 Delegating Router for prefix assignment. This is the interworking between the two functions.

### **[5.1.3](#). Packet Forwarding**

- o On receiving an IP packet from a mobile router, the mobile access gateway before tunneling the packet to the local mobility anchor MUST ensure that there is an established binding for the mobile



router and the source IP address of the packet is a prefix delegated to that mobile router. If the source address of the received IP packet is not part of the delegated mobile network prefix, then the mobile access gateway MUST NOT tunnel the packet to the local mobility anchor.

- o On receiving an IP packet from the bi-directional tunnel established with the local mobility anchor, the mobile access gateway MUST first decapsulate the packet (removing the outer header) and then use the destination address of the (inner) packet to forward it on the interface through which the mobile router is reachable.
- o The above forwarding considerations are not applicable to the IP traffic sent/received to/from the mobile router's home address (IPv4 HOA/HNP). For the mobile router's home address traffic, forwarding considerations from [\[RFC5213\]](#) and [\[RFC5844\]](#) continue to apply.

## **5.2. LMA Considerations**

### **5.2.1. Extensions to Binding Cache Entry Data Structure**

In order to support this specification, the conceptual Binding Cache Entry (BCE) data structure [\[RFC5213\]](#) needs to be extended to include delegated mobile network prefix (DMNP) list. Each entry in the list represents a delegated mobile network prefix.

### **5.2.2. Signaling Considerations**

- o If the Proxy Binding Update message does not include any Delegated Mobile Network Prefix option(s) ([Section 4.1](#)), then the local mobility anchor MUST NOT enable Delegated Prefix support for the mobility session, and the Proxy Binding Acknowledgment message that is sent in response MUST NOT contain any Delegated Mobile Network Prefix option(s).
- o If the Proxy Binding Update message includes one or more Delegated Mobile Network Prefix options, but either the local mobility anchor is not configured to support Delegated Prefix support, then the local mobility anchor will ignore the option(s) and process the rest of the option as specified in [\[RFC5213\]](#). This would have no affect on the operation of the rest of the protocol. Proxy Binding Acknowledgement message that is sent in response will not include any Delegated Mobile Network Prefix option(s).
- o If the Proxy Binding Update message has the Delegated Mobile Network Prefix option(s) and if the local mobility anchor is



configured for Delegated Prefix support, then the local mobility anchor MUST enable Delegated Mobile Network Prefix option for that mobility session. The Proxy Binding Acknowledgement message that is sent in response MUST include the Delegated Mobile Network Prefix option(s). The following considerations apply.

- \* If there is at least one instance of the Delegated Mobile Network Prefix option with a ALL\_ZERO [[RFC5213](#)] prefix value, then this serves as a request for the local mobility anchor to perform the assignment of one or more delegated mobile network prefixes.
  - + A Delegated Mobile Network option with ALL\_ZERO value and with the (V) flag set to a value of (0), is a request for the local mobility anchor to allocate one or more IPv6 prefixes.
  - + A Delegated Mobile Network option with ALL\_ZERO value and with the (V) flag set to a value of (1), is a request for the local mobility anchor to allocate one or more IPv4 prefixes.
  - + Inclusion of multiple instances of Delegated Mobile Network options with ALL\_ZERO value, one with the (V) flag set to a value of (1), and another instance with the (V) flag set to a value of (0) is a request to allocate both IPv4 and IPv6 prefixes.
- \* If there are no instances of the Delegated Mobile Network Prefix option present in the request with ALL\_ZERO value, but has a specific prefix value, then this serves as a request for the local mobility anchor to perform the allocation of the requested prefix(es).
  - + If any one of the requested prefixes are assigned to some other mobility node, or not from an authorized pool that the local mobility can allocate for that mobility session, then the Proxy Binding Update MUST be rejected by sending a Proxy Binding Acknowledgement message with Status field set to REQUESTED\_DMNP\_IN\_USE (Requested delegated mobile network prefix is in use).
- o Upon accepting the Proxy Binding Update, the local mobility anchor MUST send a Proxy Binding Acknowledgement message with the Status field set to 0 (Proxy Binding Update accepted).
- \* The message MUST include one instance of the Delegated Mobile Network Prefix option for each of the allocated IPv4/IPv6



delegated mobile network prefixes.

- \* The delegated mobile network prefix (DMNP) list in the mobile router's Binding Cache entry have to be updated with the allocated prefix(es). However, if the request is a de-registration request with a lifetime value of (0), the delegated mobile network prefix list has to be removed along with the Binding Cache entry.
- \* A route (or a platform-specific equivalent function that sets up the forwarding) for each of the allocated prefixes over the tunnel has to be added. However, if the request is a de-registration request, with a lifetime value of (0), all the IPv4/IPv6 delegated prefix routes created for that session have to be removed.

### **5.2.3. Packet Forwarding**

- o The local mobility anchor MUST advertise a connected route into the Routing Infrastructure for the IP prefixes delegated to all of the mobile routers that it is serving. This step essentially enables the local mobility anchor to be a routing anchor for those IP prefixes and be able to intercept IP packets sent to those mobile networks.
- o On receiving a packet from a correspondent node with the destination address matching any of the mobile router's delegated mobile network prefixes, the local mobility anchor MUST forward the packet through the bi-directional tunnel set up with the mobile access gateway where the mobile router is attached.
- o On receiving an IP packet from the bi-directional tunnel established with the mobile access gateway, the local mobility anchor MUST first decapsulate the packet (removing the outer header) and then use the destination address of the (inner) packet for forwarding decision. The local mobility anchor MUST ensure that there is an established binding for the mobile router and the source IP address of the packet is a prefix delegated to a mobile router reachable over that bi-directional tunnel.
- o The above forwarding considerations are not applicable to the IP traffic sent/received to/from the mobile router's home address (IPv4 HOA/HNP). For the mobile router's home address traffic, forwarding considerations from [[RFC5213](#)] and [[RFC5844](#)] continue to apply.





### 5.3. Security Policy Database (SPD) Example Entries

The use of DHCPv6, as described in this document, requires message integrity protection and source authentication. The IPsec security mechanism used by Proxy Mobile IPv6 [[RFC5213](#)] for securing the signaling messages between the mobile access gateway and the local mobility anchor can be used for securing the DHCP signaling between the mobile access gateway and the local mobility anchor.

The Security Policy Database (SPD) and Security Association Database (SAD) entries necessary to protect the DHCP signaling is specified below. The format of these entries is based on [[RFC4877](#)] conventions. The SPD and SAD entries are only example configurations. A particular implementation of mobile access gateway and local mobility anchor implementation can configure different SPD and SAD entries as long as they provide the required security for protecting DHCP signaling messages.

For the examples described in this document, a mobile access gateway with address "mag\_address\_1", and a local mobility anchor with address "lma\_address\_1" are assumed.

mobile access gateway SPD-S:

- IF local\_address = mag\_address\_1 &  
    remote\_address = lma\_address\_1 & proto = UDP &  
    local\_port = any & remote\_port = DHCP  
    Then use SA1 (OUT) and SA2 (IN)

mobile access gateway SAD:

- SA1(OUT, spi\_a, lma\_address\_1, ESP, TRANSPORT):  
    local\_address = mag\_address\_1 &  
    remote\_address = lma\_address\_1 &  
    proto = UDP & remote\_port = DHCP
- SA2(IN, spi\_b, mag\_address\_1, ESP, TRANSPORT):  
    local\_address = lma\_address\_1 &  
    remote\_address = mag\_address\_1 &  
    proto = UDP & local\_port = DHCP

local mobility anchor SPD-S:

- IF local\_address = lma\_address\_1 &  
    remote\_address = mag\_address\_1 & proto = UDP &  
    local\_port = DHCP & remote\_port = any  
    Then use SA2 (OUT) and SA1 (IN)

local mobility anchor SAD:

- SA2(OUT, spi\_b, mag\_address\_1, ESP, TRANSPORT):  
    local\_address = lma\_address\_1 &  
    remote\_address = mag\_address\_1 &



```
        proto = UDP & local_port = DHCP
-   SA1(IN, spi_a, lma_address_1, ESP, TRANSPORT):
        local_address = mag_address_1 &
        remote_address = lma_address_1 &
        proto = UDP & remote_port = DHCP
```

## **6. Security Considerations**

The Delegated Mobile Network Prefix Option defined in this specification is for use in Proxy Binding Update and Proxy Binding Acknowledgement messages. This option is carried like any other mobility header option as specified in [\[RFC5213\]](#). Therefore, it inherits from [\[RFC5213\]](#) its security guidelines and does not require any additional security considerations.

The use of DHCPv6 in this specification is as defined in DHCPv6 base specification [\[RFC3315\]](#) and DHCPv6 Prefix Delegation specifications [\[RFC3633\]](#). The security considerations specified in those specifications apply to this specification.

If IPsec is used, the IPsec security association that is used for protecting the Proxy Binding Update and Proxy Binding Acknowledgement, also needs to be used for protecting the DHCPv6 signaling between the mobile access gateway and the local mobility anchor. Considerations specified in [Section 3](#) identify the extensions to security policy entries [\[RFC4301\]](#)



## **7. IANA Considerations**

This document requires the following IANA actions.

- o Action-1: This specification defines a new Mobility Header option, Delegated Mobile Network Prefix option. This mobility option is described in [Section 4.1](#). The type value <IANA-1> for this message needs to be allocated from the Mobility Header Types 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.
- o Action-2: This document also defines two new status values NOT\_AUTHORIZED\_FOR\_DELEGATED\_MNP (Not Authorized for delegated mobile network prefix) <IANA-2> REQUESTED\_DMNP\_IN\_USE (Requested delegated mobile network prefix is in use) <IANA-3> for use in the Proxy Binding Acknowledgement message, as described in [Section 4.2](#). This value has been assigned from the same number space as allocated for other status codes [[RFC6275](#)].



## **8. Acknowledgments**

The authors would like to Acknowledge Ryuji Wakikawa, Alexandru Petrescu, Behcet Sarikaya and Seil Jeon and Basavaraj Patil for all the discussions and reviews of this draft.

The work of Carlos J. Bernardos has also been partially supported by the European Community's Seventh Framework Programme (FP7-ICT-2009-5) under grant agreement n. 258053 (MEDIEVAL project) and by the Ministry of Science and Innovation of Spain under the QUARTET project (TIN2009-13992-C02-01).



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Authors' Addresses

Xingyue Zhou  
ZTE Corporation  
No.50 Software Avenue, Yuhuatai District  
Nanjing  
China

Phone: +86-25-8801-4634  
Email: zhou.xingyue@zte.com.cn

Jouni Korhonen  
Nokia Siemens Networks  
Linnoitustie 6  
Espoo FIN-02600  
Finland

Email: jouni.nospam@gmail.com

Carl Williams  
Consultant  
San Jose, CA  
USA

Email: carlw@mcsr-labs.org

Sri Gundavelli  
Cisco  
170 West Tasman Drive  
San Jose, CA 95134  
USA

Email: sgundave@cisco.com

Carlos J. Bernardos  
Universidad Carlos III de Madrid  
Av. Universidad, 30  
Leganes, Madrid 28911  
Spain

Phone: +34 91624 6236  
Email: cjbc@it.uc3m.es  
URI: <http://www.it.uc3m.es/cjbc/>

