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A+P for Proxy Mobile IPv6
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Abstract

This memo specifies how to use IPv6 a+p technique in mobile networks for Proxy Mobile IPv6 (PMIPv6). Mobile node which is a dual-stack node can receive a shared IPv4 Home Address together with a port range from the Local Mobility Agent (LMA). LMA is co-located with Port Range Router (PRR). Mobile Access Gateway (MAG) encapsulates IPv4 datagrams in IPv6 which are decapsulated at the LMA. In the binding mode, LMA as PRR receives incoming IPv4 datagrams, determines the routing identifier, finds the binding cache entry for this MN and then encapsulates the IPv4 datagram in an IPv6 one and forwards the encapsulated datagram to MN. The stateless mode is also described. Mobile network could be WiMAX network or 3GPP Long Term Evolution (LTE) network.

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[1.](#) Introduction

[1.1.](#) Overall Context

It is commonly agreed that IPv4 address depletion is a fact. Several solutions have been proposed to cope with this sensitive issue. All these solutions are based on IP address sharing and differ in where the IP address sharing function is enforced.

The first category is denoted as Port Range [[I-D.boucadair-port-range](#)] or A+P solutions [[I-D.ymbk-aplusp](#)]. The spirit of this category is to assign the same public IP address to several customers' devices together with a Port Range. Communications issued/destined to a port-restricted device can be established only if the ports belong to the provisioned Port Range.

The second category is known as CGN (for Carrier Grade NAT). Two main CGN variants can be distinguished. Double NAT, in which two levels of NAT are cascaded: one in the CPE and one in the network (i.e. CGN) and DS-lite [[I-D.ietf-softwire-dual-stack-lite](#)] which gets rid of the CPE NAT level. DS-lite requires a Dual-Stack CPE. Thus, a given CPE is assigned with an IPv6 prefix to be used for its native IPv6 communications and also to encapsulate the IPv4 packets into IPv6 ones between the CPE and the DS-lite CGN.

The main advantage of the a+p solutions compared to the CGN-based ones is to avoid maintaining any session-state in the service provider's realm. Hurdles related to the deployment of NAT technique in the service domain and constraints to maintain various ALGs are avoided. For more information about the advantage of a+p, the reader should refer to [[I-D.ymbk-aplusp](#)] and/or [[I-D.boucadair-port-range](#)]. When deployed in the context of mobile networks, the same IPv4 address can be shared by many mobile nodes but the number of source ports they can use are limited. In the binding mode, Port Range Router in the network keeps a binding table containing the routing identifier (IPv6 address), IPv4 address and port mask. Port Range

Router receives all incoming datagrams for the shared IPv4 addresses and searches the binding table to retrieve the routing identifier and forwards the IPv4 datagram to the correct host. In the stateless mode, this binding cache is not required.

1.2. Contribution of This Memo

This document presents a mobility port-range solution combining the port range for Proxy Mobile IPv6 (PMIPv6, [[RFC5213](#)]). For Proxy Mobile IPv6, we use the router-based architecture of DS-lite. In this case MAG is the softwire initiator and it encapsulates IPv4 datagrams in IPv6 and sends them to the port range router which is

co-located with the local mobility anchor. Port range router functionality replaces DS-Lite Carrier Grade NAT (CGN). Inbound datagrams are received by the Port Range Router whose binding table is integrated with the binding cache of LMA. LMA then searches its binding cache and finds IPv6 care-of address and then encapsulates the datagram and sends it to the MAG which decapsulates it and sends it to MN.

Proxy Mobile IPv6 defines other scenarios as well in [[I-D.ietf-netlmm-pmip6-ipv4-support](#)]. Scenarios such as MAG behind a NAT which requires NAT traversal mechanisms. Using port range and DS-lite router-based architecture, the need for these more complicated operations is eliminated.

Proxy Mobile IPv6 is defined to provide network-based mobility support without any mobility signaling from the mobile nodes. Proxy Mobile IPv6 is expected to work on unmodified hosts. The solution proposed below in [Section 3](#) however requires mobile nodes to be able to request port range IPv4 addresses. Mobile node modification is inherent in this solution.

2. Terminology

This document uses the terminology defined in [[I-D.ietf-softwire-dual-stack-lite](#)], [[I-D.boucadair-port-range](#)] and [[I-D.bajko-pripaddrassign](#)], [[RFC5213](#)] and [[I-D.ietf-netlmm-pmip6-ipv4-support](#)].

3. Basic Port-Range-based PMIPv6 Solution

This section assumes that the basic Port-Range architecture as defined in [[I-D.boucadair-port-range](#)] is adopted. Particularly, a binding entry is required to associate an IPv4 address + Port Range with an IPv6 address (or IPv6 prefix). [Section 4](#) describes an alternative in which this binding is not required.

3.1. Overall Procedure

IPv4-enabled dual-stack MN can get an IPv4 Home Address. The simplest scenario is as follows: to register MN with LMA, MAG sends an IPv6 Binding Update to LMA. MAG MUST include IPv4 Home Address option defined in [[RFC5555](#)] extended with port range value and mask in the Proxy Binding Update (PBU) and set the address to 0.0.0.0. LMA assigns an IPv4 Home Address and port range and returns it in a Proxy Binding Acknowledgement (PBA) using an extended IPv4 Home Address option called IPv4 Home Address and Port Range (HoA-PR)

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defined in [Section 5](#). MN sends IPv4 datagrams to MAG. then, MAG tunnels (IPv4-in-IPv6) datagrams to LMA.

We will describe two more scenarios for IPv4 home address configuration.

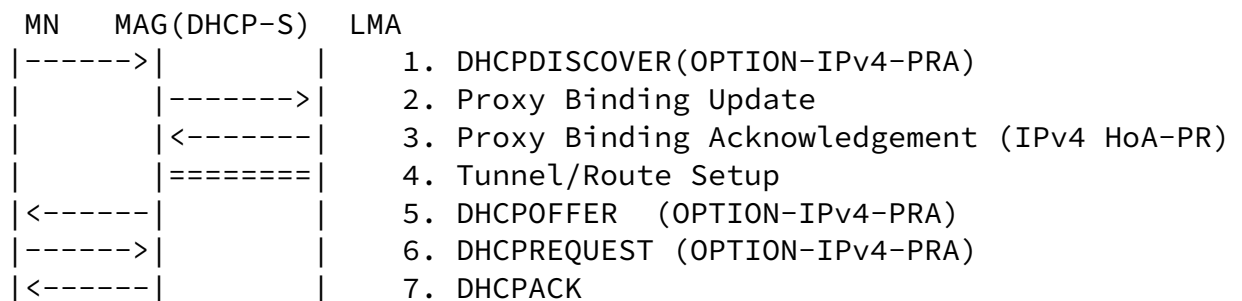


Figure 1: Mobile Node IPv4 Address Configuration - 1

Figure 1 illustrates the overall flow exchange to retrieve a shared IPv4 address. Concretely, the experienced behaviour is as follows:

1. MN enters the network. MN sends DHCPDISCOVER message to DHCP Proxy/Server [[I-D.ietf-netlmm-pmip6-ipv4-support](#)]. The message will contain OPTION-IPv4-PRA option with the sub-opt type indicating port mask (value = 1) [[I-D.bajko-pripaddressign](#)].
2. MAG registers this MN by sending a Proxy Binding Update message to LMA. MAG adds IPv4 Home Address Option with port range value and range and sets IPv4 Home Address field in the option to 0.0.0.0.
3. LMA assigns a shared IPv4 Home Address and a port range address for this MN. LMA sends Proxy Binding Acknowledgement with IPv4 Address Acknowledgement and Port Range option. If MN is dual-stack, LMA assigns Home Network Prefix(es) for MN and includes them in the PBA. LMA creates a binding in its binding cache for IPv4 HoA (and MN HNP if MN is dual-stack). In the binding cache, together with IPv4 HoA, the port range and port mask MUST also be included. LMA acting as Port Range Router also assigns MAG's IPv6 address (Proxy-CoA) (in the source address of PBU) as the binding identifier for MN. HA adds an entry containing (IPv4 HoA, port mask, port range, Proxy-CoA) to the binding table for this MN [[I-D.boucadair-port-range](#)].
4. A tunnel is established between MAG and LMA. This is DS-Lite tunnel between IPv6 address of the interface of MAG towards LMA and IPv6 address of the interface of LMA towards MAG.
5. MN receives DHCP OFFER message with the 'yiaddr' (client IP address) field set to 0.0.0.0 and with OPTION-IPv4-PRA option with the sub-opt type indicating port mask (value = 1). The

option contains the shared IPv4 address and port range and mask. DHCP Proxy/Server MUST assign the IPv4 address and port range received in Step 3 to the MN.

6. MN sends DHCP REQUEST message. MN MUST NOT include a 'Requested IP Address' DHCP option (code 50) into this DHCPREQUEST and also MUST NOT insert the IP address received in OPTION-IPv4-PRA into the 'Requested IP Address' DHCP option (code 50).
7. MN receives DHCP ACK message with OPTION-IPv4-PRA. MN uses this address as its IPv4 address.

MN	MAG(DHCP-R)	LMA	DHCP-S
		----->	1. Proxy Binding Update
		<-----	2. Proxy Binding Acknowledgement (IPv4 HoA-PR)
		=====	3. Tunnel/Route Setup

----->	----->	4. DHCPDISCOVER (OPTION-IPv4-PRA) via DHCP-R
<-----	<-----	5. DHCPOFFER (OPTION-IPv4-PRA) via DHCP-R
----->	----->	6. DHCPREQUEST (OPTION-IPv4-PRA) via DHCP-R
<-----	<-----	7. DHCPACK via DHCP-R

Figure 2: Mobile Node IPv4 Address Configuration - 2

The mobile node address configuration in Figure 2 has the following steps:

1. MN enters the network. MAG registers this MN by sending a Proxy Binding Update message to LMA. MAG adds IPv4 Home Address Option with port range value and range and sets IPv4 Home Address field in the option to 0.0.0.0.
2. LMA assigns a shared IPv4 Home Address and a port range address for this MN. LMA sends Proxy Binding Acknowledgement with IPv4 Address Acknowledgement and Port Range Option. If MN is dual-stack, LMA assigns Home Network Prefix(es) for MN and includes them in the PBA. LMA creates a binding in its binding cache for IPv4 HoA (and MN HNP if MN is dual-stack). In the binding cache, together with IPv4 HoA, the port range and port mask MUST also be included. LMA acting as Port Range Router also assigns MAG's IPv6 address (Proxy-CoA) (in the source address of PBU) as the binding identifier for MN. HA adds an entry containing (IPv4 HoA, port mask, port range, Proxy-CoA) to the binding table for this MN [[I-D.boucadair-port-range](#)].
3. A tunnel is established between MAG and LMA. This is DS-Lite tunnel between IPv6 address of the interface of MAG towards LMA and IPv6 address of the interface of LMA towards MAG.

4. MN sends DHCPDISCOVER message to DHCP Relay Agent [[I-D.ietf-netlmm-pmip6-ipv4-support](#)]. The message will contain OPTION-IPv4-PRA Option with the sub-opt type indicating port mask (value = 1) [[I-D.bajko-pripaddrassign](#)]. DHCPv4 Relay sends this message to DHCP server.
5. MN receives DHCP OFFER message with the 'yiaddr' (client IP address) field set to 0.0.0.0 and with OPTION-IPv4-PRA Option with the sub-opt type indicating port mask (value = 1). The

- option contains the shared IPv4 address and port range and mask. DHCP Server MUST assign the IPv4 address and port range received in Step 2 to the MN.
6. MN sends DHCP REQUEST message. MN MUST NOT include a 'Requested IP Address' DHCP option (code 50) into this DHCPREQUEST and also MUST NOT insert the IP address received in OPTION-IPv4-PRA into the 'Requested IP Address' DHCP option (code 50).
 7. MN receives DHCP ACK message with OPTION-IPv4-PRA. MN uses this address as its IPv4 address.

MN sends IPv4 datagrams to MAG. LMA tunnels these datagrams are tunneled to LMA using IPv4-in-IPv6 encapsulation scheme. Internal IPv4 packet's source address is IPv4 HoA. Internal IPv4 packet's source port MUST be within range defined by the port range and mask sent by LMA.

MN handoffs and gets connected to a different network. MN sends DHCP RENEW message to DHCP Proxy/Server or Relay Agent which is colocated with the new MAG. The new MAG sends a PBU to LMA to register this move. DHCP RENEW MUST include IPv4 Home Address and Port Range Options. LMA modifies the binding cache with the new Proxy-CoA for this MN. LMA MUST modify the binding table by changing the binding identifier for this IPv4 address and port range.

[3.2.](#) IPv4 Data Flow

Port Range Router colocated in LMA has to receive the incoming IPv4 datagrams for all MNs that are assigned a shared IPv4 address. This can be achieved in IGP by advertizing all port shared IPv4 addresses.

When Port Range Router receives an IPv4 datagram it searches the binding table for destination IPv4 address and port for a matching entry against IPv4 HoA, port mask and port range. If an entry is found then the binding identifier (Proxy-CoA) is determined. Next LMA searches the binding cache for IPv4 HoA and port range to verify that there is a binding cache entry for this MN. HA tunnels the received IPv4 datagram to the MAG at the destination address of Proxy-CoA.

When MN has IPv4 data to send MN always sends the datagram in IPv4 to

the MAG it is currently connected. MAG encapsulates IPv4 datagrams

in IPv6 and sends them to LMA in the MAG-LMA tunnel. LMA decapsulates the datagram. LMA MUST verify the source address and source port in the inner header using the tunnel header's source address to find the corresponding binding cache entry.

4. IPv6 Port-Range-based Mobile IPv6 Solution: stateless mode

If the network is configured as DS-lite network [[I-D.ietf-softwire-dual-stack-lite](#)] the following two implications should be taken into account:

In the scenario in Figure 2, it is not possible for DHCPv4 Relay Agent to communicate with DHCPv4 Server in IPv4. Mobile Access Gateway (collocated with DHCPv4 Relay) has to encapsulate DHCPv4 messages in IPv6 before sending them to DHCPv4 Server. Alternatively, DHCPv6 can be used to provision the shared IPv4 address and the Port Range as defined in [[I-D.boucadair-dhcpv6-shared-address-option](#)].

IPv4-enabled mobile nodes make DNS requests in IPv4. For that purpose they need to be configured with the address of an IPv4 DNS resolver. The DNS resolver then forwards the DNS request from the mobile nodes over IPv6 to the IPv6 DNS resolver address it has received over DHCPv6. DNS resolver for IPv4 must be a DNS proxy as described in [[I-D.ietf-softwire-dual-stack-lite](#)].

When a stateless mode is adopted, MNs are assigned with an IPv6 prefix which enclose the shared IPv4 address and the significant bits of the Port Range.

For outgoing communications, the same behaviour as described in [Section 3.2](#) applies.

For incoming communications, the PRR does not need to maintain any binding table to map the shared IPv4 address, port range and an IPv6 address. The PRR builds an IPv6 address using the destination IPv4 address and source number. The PRR MUST be configured with the Pref6. The IPv4 datagram is then encapsulated in an IPv6 one and sent to the aforementioned IPv6 address. The encapsulated datagram is received by the MN which proceeds to a de-capsulation operation. Encapsulated IPv4 datagram is then treated according to normal behaviour.

This mode is completely stateless (except for the mobility management aspects), i.e. no binding table is needed.

5. Extensions to Proxy Mobile IPv6

5.1. Proxy Binding Update Extensions

IPv4 Home Address Option defined in [RFC5555] is extended to also carry the port range value and mask and this new option is called IPv4 Home Address and Port Range Option.

This option is included in the mobility header, including the proxy binding update message sent from the mobile access gateway to the local mobility anchor.

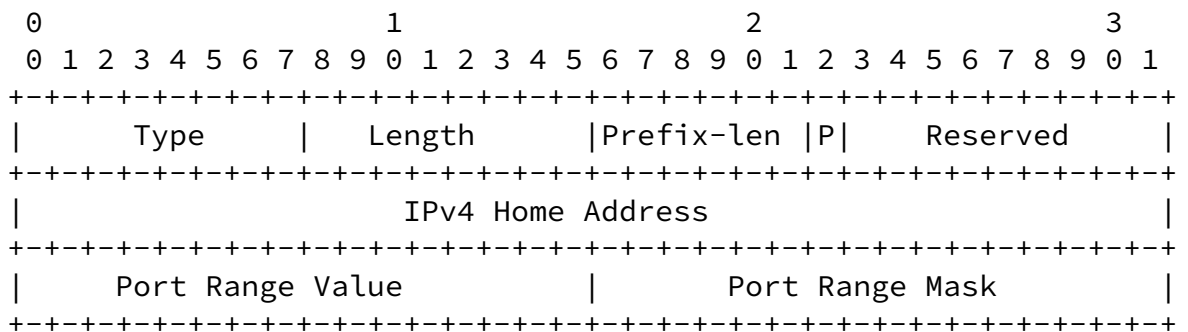


Figure 3: IPv4 Home Address and Port Range Option

Type

TBA1 for Type
Length

10
Prefix-len

As defined in [RFC5555]
P

As defined in [RFC5555]
Reserved

As defined in [RFC5555]
IPv4 home address

As defined in [RFC5555]. Mobile access gateway MUST set this field to 0.0.0.0.

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Port Range Value

16-bit field that indicates the value of the mask to be applied.
Mobile access gateway must set this field to all zeros.

Port Range Mask

16-bit field that indicates the position of the bits which are used to build the mask. Mobile access gateway must set this field to all zeros.

5.2. Proxy Binding Acknowledgement Extensions

IPv4 Home Address Acknowledgement option defined in [RFC5555] is extended to also carry the port range value and mask and this new option is called IPv4 Home Address and Port Range Acknowledgement Option.

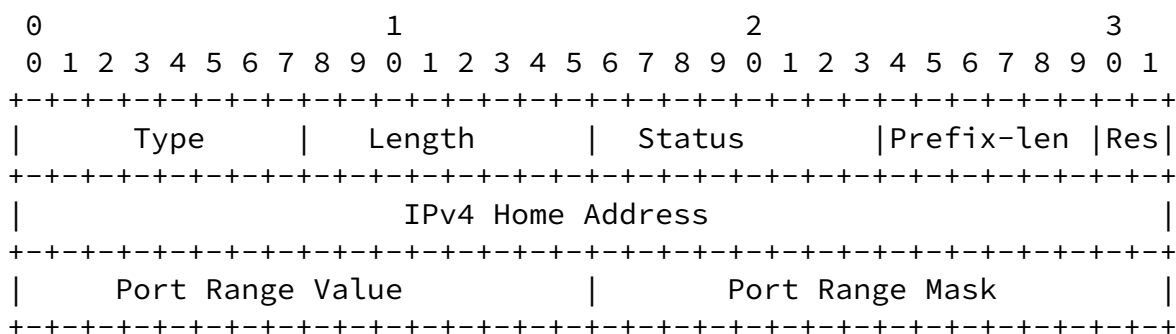


Figure 4: IPv4 Home Address and Port Range Acknowledgement Option

Type

TBA2 for Type

Length

10

Prefix-len

As defined in [[RFC5555](#)]
Res

As defined in [[RFC5555](#)]
IPv4 home address

As defined in [[RFC5555](#)]. Local mobility anchor sets this field to the value that it will use in the binding cache entry. This address is a public address.

Port Range Value

16-bit field that indicates the value of the mask to be applied. Local mobility anchor must set this field to a valid port range value.

Port Range Mask

16-bit field that indicates the position of the bits which are used to build the mask. Local mobility anchor must set this field to a valid port range mask.

Status

The following values are allocated in addition to the ones defined in [[RFC5555](#)].

- o 140 Dynamic IPv4 home address assignment with port range feature not available
- o 141 No address/port left

[6.](#) Security Considerations

TBD.

[7.](#) IANA Considerations

TBD.

[8.](#) Acknowledgements

TBD.

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