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A+P for Dual-Stack Mobile IPv6
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Abstract

This memo describes how to use IPv6 Port Range transition technique in mobile networks for Dual-Stack Mobile IPv6 (DSMIPv6). Using the client based DSMIPv6, a mobile node (MN) which is a dual-stack node can be assigned with a shared IPv4 Home Address (HA) together with a port range from the home agent. HA is co-located with Port Range Router (PRR). IPv4-in-IPv6 encapsulation is used to convey IPv4 traffic between the network and the mobile node (MN). HA, acting as PRR receives incoming IPv4 datagrams and determines the routing identifier (IPv6 address) to use to forward the traffic to the appropriate MN among those sharing the same IPv4 address. In the binding mode, HA 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. Within this memo, 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 aims at assessing the validity of the a+p approach in the context of Dual-Stack Mobile IPv6 (DSMIPv6 [[RFC5555](#)]). This is mainly motivated by the need to avoid maintaining NAT (and therefore, no need to deploy ALGs, session states in the service realm, etc.) in the path to enhance the overall experienced performance (e.g.,

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latency). Mobile Nodes may or may not embed a NAT function.

This document presents a mobility solution combining the Port Range-based architecture and Client Mobile IPv6 [[RFC5555](#)]. Both a binding mode and stateless mode are described.

Client Mobile IPv6 defines other scenarios as well in [[RFC5555](#)]. IPv4-only scenario and its variations such as mobile node behind a NAT which could be located at the home router and therefore requires NAT traversal mechanisms and home agent behind NAT but home agent has a globally unique IPv4 address. Using Port Range-based architecture solution over an IPv6-enabled network, the need for these more complicated operations is eliminated.

[2.](#) Terminology

This document uses the terminology defined in [[I-D.ietf-softwire-dual-stack-lite](#)], [[I-D.boucadair-port-range](#)], [[I-D.bajko-pripaddrassign](#)] and [[RFC5555](#)].

3. On Port Range Value and Port Range Mask

Devices with shared IPv4 addresses are provisioned also with a port range to be used, especially the Port Mask to be applied when selecting a port value as a source port. A Port Mask defines a set of ports that all have in common a subset of pre-positioned bits. This set of ports is also called Port Range. Two port numbers are said to belong to the same Port Range if and only if, they have the same Port Mask. A Port Mask is composed of a Port Range Value and a Port Range Mask:

- o The Port Range Value indicates the value of the significant bits of the Port Mask. The Port Range Value is coded as follows:
 - * The significant bits may take a value of 0 or 1.
 - * All the other bits (non significant ones) are set to 0.
- o The Port Range Mask indicates, by the bit(s) set to 1, the position of the significant bits of the Port Range Value.

An example of port range is provided in Figure 1. Ports belonging to this port range must have the first 3 bits equal to 001. The Port Mask is represented as: 001xxxxxxxxxxxxx.

```

                                0                                1
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0| Port Range Mask
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
| | |
| | | (3 significant bits)
v v v
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0| Port Range Value
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|0 0 1 x x x x x x x x x x x x x x| Usable ports (x may take a value of 0 or 1).
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
```

Figure 1: Example of Port Range Mask and Port Range Value

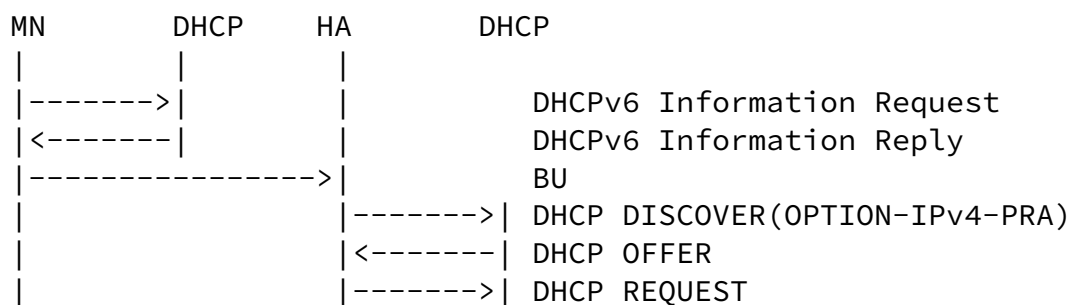
For more details, refer to [[I-D.bajko-pripaddrassign](#)].

4. Basic Port-Range-based Mobile IPv6 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 5](#) describes an alternative in which this binding is not required.

4.1. Overall Procedure

Dual-stack MN can get an IPv4 home address by sending an IPv6 Binding Update (BU) to the Home Agent (HA). MN MUST include IPv4 Home Address Option defined in [[RFC5555](#)] in the BU and set the address to 0.0.0.0. HA assigns an IPv4 Home Address together with Port Range and returns it in a BA using an extended IPv4 Home Address Option called IPv4 Home Address and Port Range (HoA-PR) defined in [Section 6](#). MN encapsulates all its IPv4 datagrams into IPv6 ones and forwards encapsulated datagrams to HA. MN does not need to configure an IPv4 care-of address as MN uses the IPv6 connectivity.



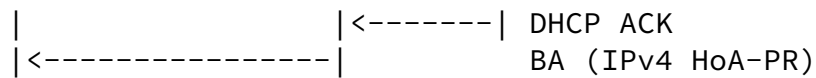


Figure 2: Mobile Node Address Configuration

Figure 2 illustrates the overall flow exchange to retrieve a shared IPv4 address. Concretely, the experienced behaviour is as follows:

1. MN enters the network. MN autoconfigures IPv6 Care-of Address (e.g., 2001:0:0:1::1). MN needs to be provided with an IPv6 address (e.g., 2001:0:0:2::1) of the HA and an IPv6 Home Address. MN sends DHCPv6 Information Request message to DHCP Proxy/Server as specified in [\[I-D.ietf-mip6-hiopt\]](#).
2. DHCP Proxy/Server sends a Reply message with IPv6 and IPv4 address of IPv6 HA and Home Network Prefix values for MN.
3. MN registers then its IPv6 CoA by sending a BU to HA. MN adds IPv4 Home Address Option and sets IPv4 Home Address field in HoA-PR Option to 0.0.0.0.
4. HA MAY send DHCP DISCOVER message to DHCPv4 server. The message will contain OPTION-IPv4-PRA Option with the sub-opt type indicates port mask (value = 1) [\[I-D.bajko-pripaddrassign\]](#).
5. HA receives DHCP OFFER message with the 'yiaddr' (client IP address) field set to 0.0.0.0 and with OPTION-IPv4-PRA Option. The option contains the shared IPv4 address and Port Range and mask.
6. HA sends DHCP REQUEST message. HA 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. HA receives DHCP ACK message with OPTION-IPv4-PRA. HA assigns the address in IPv4 address field to MN as its Home Address.
8. HA sends BA with IPv4 Address Acknowledgement and Port Range Option.

HA assigns a shared IPv4 HoA to MN (a.b.c.d) and sets this value in IPv4 Home Address field of BA. HA also assigns Port Range Value and Port Range Mask of BA. HA creates a binding in its binding cache for both MN IPv6 HoA and IPv4 HoA. In the binding cache, together with HoA, the port range value and port range mask MUST also be included.

Care-of Address (CoA) (in the source address of BU) as the binding identifier for MN. HA adds an entry containing (IPv4 HoA, port range mask, port range value, IPv6 CoA) to the binding table for this MN [[I-D.boucadair-port-range](#)].

MN sends IPv4 datagrams encapsulated in IPv6. All datagrams are forwarded to HA. Internal IPv4 packet's source address is IPv4 HoA. Internal IPv4 packet's source port MUST be within the Port Range sent by HA to the MN.

MN handoffs and gets connected to a different network. MN gets another IPv6 Care-of-Address, possibly using stateless address configuration or using DHCPv6 [[RFC3315](#)]. MN sends a BU to HA to register its new Care-of-Address. MN with a shared IPv4 Home Address MUST include IPv4 Home Address and Port Range Option. MN MUST NOT start transmitting datagrams before it receives a BA.

[4.2.](#) IPv4 Data Flow

Port Range Router collocated in HA 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 range mask and port range value. If an entry is found then the binding identifier (IPv6 CoA) is determined. Next HA searches the binding cache for IPv6 CoA to verify that there is a binding cache entry for this MN. HA tunnels the received IPv4 datagram to MN.

When MN has IPv4 data to send MN always encapsulates the datagram in IPv6 and sends it to HA. HA decapsulates the datagram. HA 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.

[5.](#) IPv6 Port-Range-based Mobile IPv6 Solution

[5.1.](#) Overview

If the network is configured as DS-lite network [[I-D.ietf-softwire-dual-stack-lite](#)] or as specified in [[I-D.boucadair-behave-ipv6-portrange](#)] the following two implications should be taken into account:

DSMIPv6 Home Agent does not have a DHCPv4 server to get port range IPv4 addresses as depicted in Figure 2 in Steps 4-7. In this case Home Agent MUST locally manage IPv4 addresses it assigns to the mobile nodes. 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](#)].

5.2. Procedure

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. The format of the IPv6 prefix is as follows:

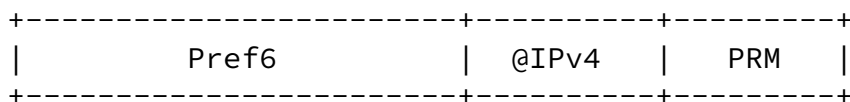


Figure 3: IPv6 prefix enclosing an IPv4 address and a port range

1. Pref6: is a sub-prefix belonging to the service provider or well-known prefix allocated by IANA for this service. The length of this field is variable (may be different from a service provider to another if not allocated by IANA).
2. @IPv4 field encloses the shared IPv4 address. The length of this field is 32 bits;
3. PRM field includes the value of the significant bits of the Port Range. The maximum length of this field is 16 bits.

For outgoing communications, the same behaviour as described in [Section 4.2](#) 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.

6. Extensions to DSMIPv6

6.1. Binding Update Extensions

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

This option is included in the mobility header, including the binding update message sent from the mobile node to a home agent.

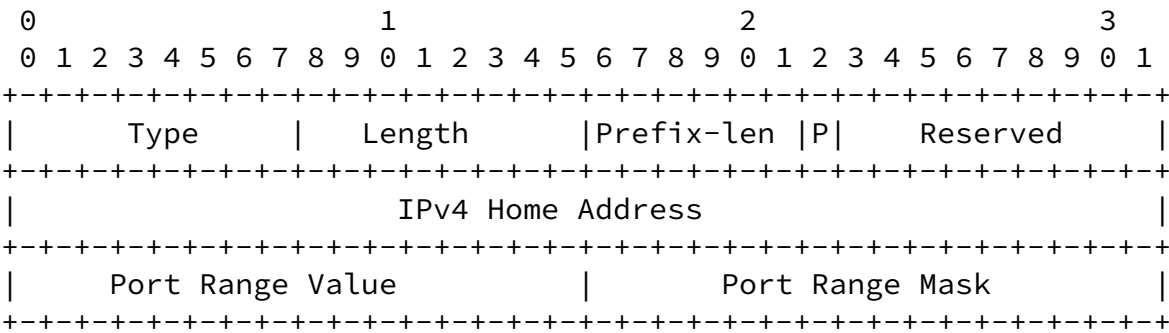


Figure 4: IPv4 Home Address and Port Range Option

Type

TBA1 for Type

Length

10

Prefix-len

Figure 5: IPv4 Home Address and Port Range Acknowledgement Option

Type

TBA2 for Type
Length

10
Prefix-len

As defined in [[RFC5555](#)]

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Res

As defined in [[RFC5555](#)]
IPv4 Home Address

As defined in [[RFC5555](#)]. Home agent 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. Home agent 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. Home agent 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

[7.](#) Security Considerations

This document does not by itself introduce any security issues.

[8.](#) IANA Considerations

TBD.

[9.](#) Acknowledgements

TBD.

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