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DHCPv6 Prefix Delegation for NEMO
draft-ietf-mext-nemo-pd-06

Abstract

   One aspect of network mobility support is the assignment of a prefix
   or prefixes to a Mobile Router (MR) for use on the links in the NEMO.
   DHCPv6 prefix delegation can be used for this configuration task.

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Table of Contents

1. Introduction

One aspect of network mobility support is the assignment of a prefix
or prefixes to a Mobile Router for use on the links in the NEMO.
DHCPv6 prefix delegation [RFC3633] (DHCPv6PD) can be used for this
configuration task.

2. 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 [RFC2119].

The following terms used in this document are defined in the IPv6
Addressing Architecture document [RFC4291]:

   Link-Local Unicast address

   Link-Local Scope Multicast address

The following terms used in this document are defined in the Mobile
IPv6 specification [I-D.ietf-mext-rfc3775bis]:

   Home Agent (HA)

   Home Link

The following terms used in this document are defined in the Mobile
Network terminology document [RFC4885]:

   Mobile Router (MR)

   Mobile Network (NEMO)

   Mobile Network Prefix (MNP)

The following terms used in this document are defined in the DHCPv6
[RFC3315] and DHCPv6 prefix delegation [RFC3633] specifications:

   Delegating Router (DR; acts as a DHCPv6 server)

   Requesting Router (RR; acts as a DHCPv6 client)

   DHCPv6 Relay Agent (DRA)

The following acronym is used in this document:

DHCPv6PD: DHCPv6 Prefix Delegation

[3]. DHCPv6 Prefix Delegation of Mobile Network Prefixes

The NEMO Basic Support protocol [RFC3963] extends the Mobile IPv6
protocol [I-D.ietf-mext-rfc3775bis] to enable network mobility. In
this extension, an MR uses the Mobile IPv6 protocol to establish and
maintain a session with its HA, and uses bidirectional tunneling
between the MR and HA to provide a path through which nodes attached
to links in the NEMO can maintain connectivity with nodes not in the
NEMO.

The requirements for NEMO [RFC4885] include the ability of the MR to
receive delegated prefixes that can then be assigned to links in the
NEMO. DHCPv6PD can be used to meet this requirement for prefix
delegation.

To use DHCPv6PD for NEMOs, the HA assumes the role of the DR, and the
MR assumes the role of the RR when located at home, and the role of a
DRA co-located with the RR function, when the MR is away from home.

When the MR is not at home, the HA and MR exchange DHCPv6PD protocol
messages as specified in RFC3775bis. This means that messages sent
by the MR include the Home Address destination option and messages
sent by the HA make use of a Routing Header type 2. See Figure 1 for
the deployment topologies when the MR is at home and when it is
visiting a foreign network.

```
              ------               ------
             | MR |----------------| HA |
             |(RR)| (home network) |(DR)|
              ------               ------


         -------    /-----------\     ------
        | MR  |----|  Internet |-----| HA |
        |(RR) |    \-----------/     |(DR)|
        |(DRA)|                       ------
         -------
      (visited network)
```
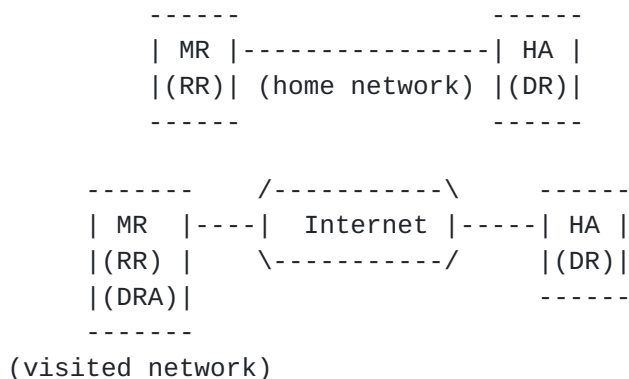
Figure 1: Deployment topologies of the use of DHCPv6PD for delegation
                             of MNPs

The DHCPv6PD server is provisioned with prefixes to be assigned using
any of the prefix assignment mechanisms described in the DHCPv6PD
specifications. Other updates to the HA data structures required as
a side effect of prefix delegation are specified by the particular

network mobility protocol. For example, in the case of Basic Network
Mobility Support [RFC3963], the HA would add an entry in its binding
cache registering the delegated prefix to the MR to which the prefix
was delegated.

3.1. Exchanging DHCPv6 messages when the MR is not at home

The case when the MR is away from home is described in this section.
Section 3.2 describes the protocol operation for the case when the MR
is attached to its home link.

The MR MUST register at the HA (i.e. by sending a Binding Update to
the HA) before initiating a DHCPv6 message exchange for prefix
delegation. Since the MR may not have yet requested any prefixes,
implicit BU signaling MUST be used. While using the NEMO Basic
Support protocol with DHCPv6PD, implicit BU signaling is the default
mode of operation.

If the MR does not have any active delegated prefixes (with unexpired
leases), the MR initiates a DHCPv6 message exchange with a DHCPv6
Solicit message as described in section 17 of RFC 3315 and section
11.1 of RFC 3633. The Delegating Router at the HA responds with an
Advertise message. Then, the MR requests a set of prefixes by
sending a Request message. The DR includes the delegated prefixes in
a Reply message. Note that in this case, the MR has previously sent
a BU to the HA without knowing yet the set of prefixes that it can
use as MNPs. The HA, upon reception of the implicit BU from the MR,
selects (in case this was not pre-configured already) the prefixes
that would then be delegated to the MR via DHCPv6PD. The HA, once
the DHCPv6 signaling has been completed, adds an entry in its binding
cache including the delegated prefixes.

In case the MR has one or more active delegated prefixes -- as for
example if the MR reboots or the MNP(s) currently used by the is
about to expire -- the MR initiates a DHCPv6 message exchange with a
DHCPv6 Rebind message as described in section 18.1.2 of RFC 3315 and
section 12.1 of RFC 3633.

A DHPCv6 relay agent function [RFC3315] is used at the MR. This
relay agent function is co-located in the MR with the DHCPv6 client
function (see Figure 2). The DHCPv6 signaling between the MR and the
HA are exchanged between the DHCPv6 relay agent in the MR and the
DHCPv6 server on the HA. DHCPv6 messages from the MR to the HA are
unicast packets sent from the unicast HoA of the MR to the global
unicast address of the HA, and therefore the Home Address destination
option is used. DHCPv6 replies from the HA to the MR are sent using
the Routing Header type 2, as specified in RFC3775bis. The DHCPv6
client in the MR hands any outbound DHCPv6 messages to the co-located

relay agent. Responses from the DHCPv6 server are delivered to the
relay agent function in the MR, which extracts the encapsulated
message and delivers it to the DHCPv6 client in the MR.

```
   -----------------------------                 --------
   |             MR              |               |  HA  |
   | (RR)                 (DRA)  |               | (DR) |
   -----------------------------                 --------
        |                     |      Binding Update  |
        |                     |------------------------>|
        |                     |         (HoA, CoA)      |
        |                     |                         |
        |                     |       Binding Ack       |
        |                     |<------------------------|
        |                     |                         |
        | DHCPv6 Solicit      |   DHCPv6 Solicit        |
        |..................>|--====================->|
        |                     |                         |
        |  DHCPv6 Advertise   |     DHCPv6 Advertise    |
        |<..................|<-====================--|
        |                     |                         |
        | DHCPv6 Request      |     DHCPv6 Request      |
        |..................>|--====================->|
        |                     |                         |
        |      DHCPv6 Reply   |     DHCPv6 Reply        |
        |<..................|<-====================--|
        |                     | (Mobile Network Prefix) |
        |                     |                         |
```
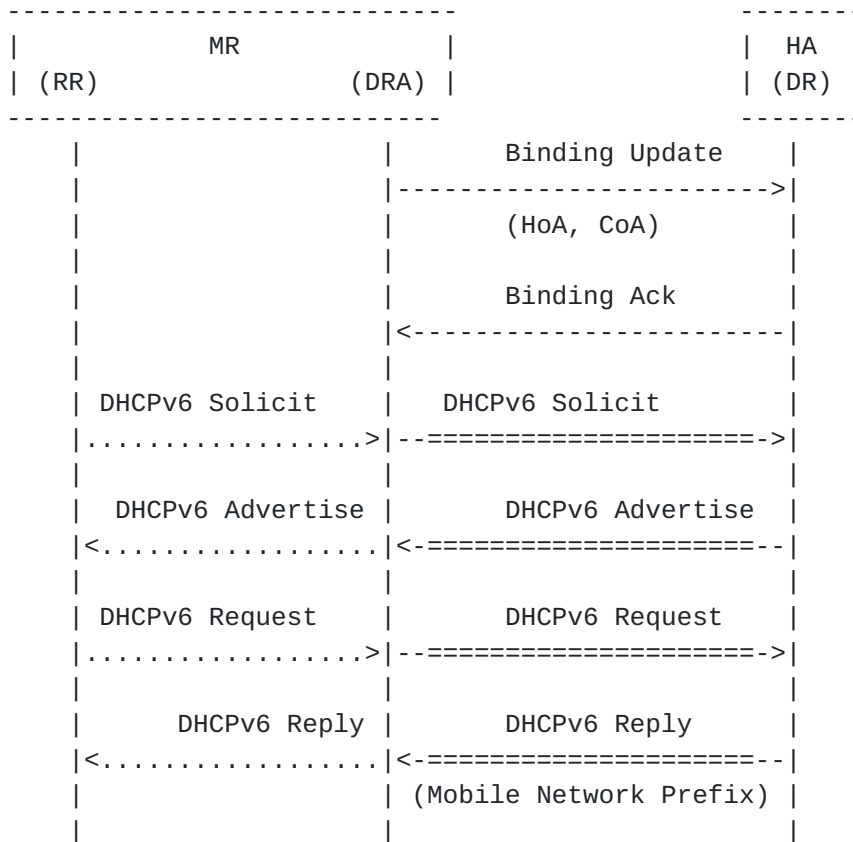
Figure 2: Signaling sequence when the MR is not at home

Note that an MR using DHCPv6PD to obtain the set of prefixes to be
used as MNPs cannot derive its HoA from an MNP (as the MR does not
know them before registering to the HA). Therefore, the MR is
assigned its HoA from the prefix on its Home Link.

3.1.1. Relay agent configuration

The use of the relay agent function in the MR allows the MR to
unicast DHCPv6 messages to the DHCPv6 server. The relay agent MUST
be configured with the address of the DHCPv6 server. For the
purposes of NEMO, the relay agent assumes that the HA for the MR
hosts the DHCPv6 server. Therefore, the MR MUST configure the DHCPv6
relay agent to forward DHCPv6 messages to the HA.

3.1.2. Transmission of DHCPv6 messages

When the DHCPv6 client in the MR sends a message, it hands the
message to the DHCPv6 relay agent in the MR. The way in which the
message is passed to the DHCP relay agent is beyond the scope of this
document. The relay agent encapsulates the message from the client
according to RFC 3315 in a Relay-forward message and sends the
resulting DHCPv6 message to the HA. The relay agent sets the fields
in the Relay-forward message as follows:

msg-type   RELAY-FORW

hop-count   1

link-address   The home address of the MR

peer-address   A non-link-local address from the MR egress interface
                (e.g., home address) used to send packets between the
                HA and the MR

options   MUST include a "Relay Message option" [RFC3315]; MAY
                include other options added by the relay agent.

3.1.3. Receipt of DHCPv6 messages

Messages from the DHCPv6 server will be returned to the DHCPv6 relay
agent, with the message for the DHCPv6 client encapsulated in the
Relay Message option [RFC3315] in a Relay-reply message. The relay
agent function extracts the message for the client from the Relay
Message option and hands the message to the DHCPv6 client in the MR.
The way in which the message is passed to the client is beyond the
scope of this document.

3.2. Exchanging DHCPv6 messages when MR is at home

When the MR is on its home link, the HA uses the home link to
exchange DHCPv6PD messages with the MR (Figure 3). In this case, the
DHCPv6 co-located relay function is disabled. It is the
responsibility of the implementation to determine when the MR is on
its home link. The Home Link Detection mechanism is described in the
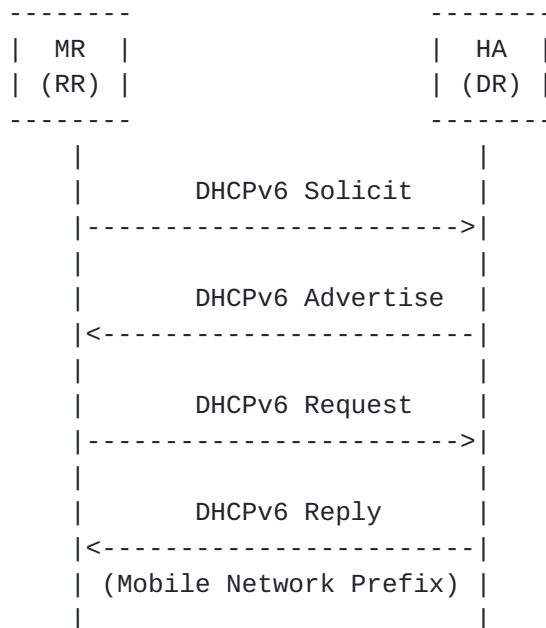section 11.5.2 of RFC3775bis.

```
                    --------                      --------
                    |  MR  |                      |  HA  |
                    | (RR) |                      | (DR) |
                    --------                      --------
                       |                             |
                       |          DHCPv6 Solicit     |
                       |---------------------------->|
                       |                             |
                       |          DHCPv6 Advertise   |
                       |<----------------------------|
                       |                             |
                       |          DHCPv6 Request     |
                       |---------------------------->|
                       |                             |
                       |          DHCPv6 Reply       |
                       |<----------------------------|
                       | (Mobile Network Prefix)     |
                       |                             |
```

Figure 3: Signaling sequence for the case the HA is at home

3.3. Selecting an HA that provides DHCPv6PD

Not all nodes that are willing to act as an HA are required to
provide DHCPv6PD. Therefore, when selecting an HA, an MR that
requires DHCPv6PD service must identify an HA that will provide the
service. The MR can determine if an HA provides DHCPv6PD by
initiating a DHCPv6 message exchange (i.e. sending a Solicit message)
in which the MR requests delegated prefix(es). If the HA does not
respond or responds but does not delegate any prefix(es) in its
response, the MR assumes that the HA does not provide DHCPv6PD
service. The MR continues to query all candidate HAs until it finds
an HA that provides DHCPv6PD. Note that in this particular case and
if the MR is away from home, the MR has to have already performed an
MIPv6 registration with the HA it queries.

Querying an HA to determine if it provides DHCPv6PD requires a small
modification to the operation of DHCPv6 as described in RFC 3315.
Under normal circumstances, a host will continue to send DHCPv6
Solicit messages until it receives a response (see Section 17 of RFC
3315). However, an HA may choose not to respond to the Solicit
messages from the MR because the HA does not provide DHCPv6.
Therefore, when querying an HA to determine if the HA provides
DHCPv6PD service, the MR SHOULD discontinue sending Solicit messages
to the HA after sending 6 Solicit messages, and conclude that the HA
will not provide DHCPv6PD service. Sending 6 queries provides enough
reliability for scenarios in which the wireless connectivity is lost
for a short period after sending the first BU message.

It is recommended that the MR uses a sequential probing of the HAs
for DHCPv6PD service.

[3.4](). **Minimizing DHCPv6PD messages**

DHCPv6PD in a NEMO can be combined with the Rapid Commit option
[RFC3315] to provide DHCPv6 prefix delegation with a two message
exchange between the mobile router and the DHCPv6PD DR.

[3.5](). **Other DHCPv6 functions**

The DHCPv6 messages exchanged between the MR and the HA MAY also be
used for other DHCPv6 functions in addition to DHCPv6PD. For
example, the HA MAY assign global addresses to the MR and MAY pass
other configuration information such as a list of available DNS
recursive name servers [RFC3646] to the MR using the same DHCPv6
messages as used for DHCPV6PD.

The HA MAY act as a DHCPv6 relay agent for Mobile Nodes while it acts
as a DR for MRs.

[4](). **Security Considerations**

This document describes the use of DHCPv6 for prefix delegation in
NEMO. In addition to the security considerations for DHCPv6
described in the "Security Considerations" section of the DHCPv6 base
specification [RFC3315] and the "Security Considerations" of the
DHCPv6 Prefix Delegation specification [RFC3633], there are two
aspects that need to be considered.

First, the NEMO Basic Support specification requires the HA to
prevent an MR from claiming MNPs belonging to another MR. Upon
reception of an implicit BU from an MR, the HA MUST only add prefixes
into the MR's Binding Cache Entry if the MR has a valid DHCPv6 Prefix
Delegation lease for said prefixes. If the MR does not have a valid
DHCPv6 Prefix Delegation lease, the HA MUST NOT add any prefixes into
the MR's Binding Cache Entry. Upon the MR obtaining a valid DHCPv6
Prefix Delegation lease for a given set of prefixes, the HA MUST add
these prefixes to the MR's Binding Cache Entry. This avoids the HA
forwarding traffic addressed to prefixes that have not been yet
delegated to the MR.

The use of DHCPv6, as described in this document, requires message
integrity protection and source authentication. When the MR is at
home, normal DHCPv6 operation is used between MR and HA and therefore
this specification does not add any new security issue. While the MR
is away from home, the IPsec security mechanism mandated by MIPv6

MUST be used to secure the DHCPv6 signaling. In the following, we
describe the Security Policy Database (SPD) and Security Association
Database (SAD) entries necessary to protect the DHCPv6 signaling. We
use the same format than that used by of [RFC4877]. The SPD and SAD
entries are only example configurations. A particular mobile router
implementation and a home agent implementation could configure
different SPD and SAD entries as long as they provide the required
security of the DHCPv6 signaling messages.

For the examples described in this document, a mobile router with
home address "home_address_1", and a home agent with address
"home_agent_1" are assumed. If the home address of the mobile router
changes, the SPD and SAD entries need to be re-created or updated for
the new home address.

```
    mobile router SPD-S:
      - IF local_address = home_address_1 &
            remote_address = home_agent_1 & proto = UDP &
            local_port = any & remote_port = DHCP
        Then use SA1 (OUT) and SA2 (IN)

    mobile router SAD:
      - SA1(OUT, spi_a, home_agent_1, ESP, TRANSPORT):
            local_address = home_address_1 &
            remote_address = home_agent_1 &
            proto = UDP & remote_port = DHCP
      - SA2(IN, spi_b, home_address_1, ESP, TRANSPORT):
            local_address = home_agent_1 &
            remote_address = home_address_1 &
            proto = UDP & local_port = DHCP

    home agent SPD-S:
      - IF local_address = home_agent_1 &
            remote_address = homa_address_1 & proto = UDP &
            local_port = DHCP & remote_port = any
        Then use SA2 (OUT) and SA1 (IN)

    home agent SAD:
      - SA2(OUT, spi_b, home_address_1, ESP, TRANSPORT):
            local_address = home_agent_1 &
            remote_address = home_address_1 &
            proto = UDP & local_port = DHCP
      - SA1(IN, spi_a, home_agent_1, ESP, TRANSPORT):
            local_address = home_address_1 &
            remote_address = home_agent_1 &
            proto = UDP & remote_port = DHCP
```

5. IANA Considerations

   This document describes the use of DHCPv6 for prefix delegation in
   NEMOs. It does not introduce any additional IANA considerations.

6. Acknowledgments

   The authors would like to thank people who have given valuable
   comments on the mailing list. Specific suggestions from Ryuji
   Wakikawa, George Tsirtsis, Alexandru Petrescu, Vijay Devarapalli and
   Marcelo Bagnulo were incorporated into this document.

   The authors would like to thank Julien Laganier, Michaela Vanderveen
   and Jean-Michel Combes for their review of previous versions of this
   document.

7. Change Log

   This section MUST be removed before this document is published as an
   RFC.

7.1. Revision -00

   This document is based on draft-ietf-nemo-dhcpv6-pd-03 and includes
   the use of the DHCPv6 relay agent in the MR from
   draft-dupont-mext-dhcrelay-00.

7.2. Revision -01

   Added detail in Section 4, "Security Considerations", describing
   protection required for DHCPv6 and a mechanism for protecting traffic
   between the DHCPv6 relay agent and server.

   Corrected minor typos.

7.3. Revision -02

   Removed text describing extensions to DHAAD for discovery of HA that
   will provide PD.

   Added Section 3.3, "Selecting an HA that provides DHCPv6PD," which
   describes how an MR can discover DHCPv6PD service through polling of
   multiple HAs.

   Added text to Section 4, "Security Considerations", giving detail
   about the use of IPsec.

7.4. Revision -04

Added some figures to better explaining considered topologies and message exchanges. Credits to Alex Petrescu.

Added some text to clarify that two BUs are required, one to set up the tunnel to the HA so the DHCPv6 signaling can be sent, and one to register the delegated prefixes as MNPs at the HA. This updates RFC 3963 behavior (note added).

Text added to address some comments received on the MEXT mailing list

Corrected minor typos.

Enlisted Carlos J. Bernardos as co-author

7.5. Revision -05

Only implicit BU mode supported.

Only DHCPv6 relay agent in the MR co-located with the DHCPv6 client function is supported as mode of operation when the MR is away from home.

Security considerations include now the issue of the HA enforcing that the MR registers the prefixes that were delegated to it via DHCPv6PD.

Since RFC3775bis specifies that MR and HA operate in RO mode when sending traffic between them, the term tunnel has been removed.

Some typos detected and corrected.

7.6. Revision -06

Some nits fixed.

8. References

8.1. Normative References

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8.2. Informative References

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