MEXT Working Group   R. Wakikawa (Ed.)
Internet-Draft   Toyota ITC/Keio Univ.
Intended status: Standards Track   V. Devarapalli (Ed.)
Expires: March 1, 2009   Wichorus
                                                              T. Ernst
                                                                 INRIA
                                                             K. Nagami
                                                          INTEC NetCore
                                                       August 28, 2008

Multiple Care-of Addresses Registration
draft-ietf-monami6-multiplecoa-09.txt

Status of this Memo

Copyright Notice

Abstract

   According to the current Mobile IPv6 specification, a mobile node may
   have several care-of addresses, but only one, called the primary
   care-of address, that can be registered with its home agent and the
   correspondent nodes. However, for matters of cost, bandwidth, delay,
   etc, it is useful for the mobile node to get Internet access through
   multiple accesses simultaneously, in which case the mobile node would
   be configured with multiple active IPv6 care-of addresses. This
   document proposes extensions to the Mobile IPv6 protocol to register
   and use multiple care-of addresses. The extensions proposed in this
   document can be used by Mobile Routers using the NEMO (Network
   Mobility) Basic Support protocol as well.

Table of Contents

[1](#). **Introduction**

   A mobile node may use various types of network interfaces to obtain
   durable and wide area network connectivity. This is increasingly
   become true with mobile nodes having multiple interfaces such as
   802.2, 802.11, 802.16, cellular radios, etc.. The motivations for
   and benefits of using multiple points of attachment are discussed in
   [ID-MOTIVATION]. When a mobile node with multiple interfaces uses
   Mobile IPv6 [RFC-3775] for mobility management, it cannot use its
   multiple interfaces to send and receive packets while taking
   advantage of session continuity provided by Mobile IPv6. This is
   because Mobile IPv6 allows the mobile node to only bind one care-of
   address at a time with its home address. See [ID-MIP6ANALYSIS] on a
   further analysis of using multiple interfaces and addresses with
   Mobile IPv6.

   This document proposes extensions to Mobile IPv6 to allow a mobile
   node to register multiple care-of addresses for a home address and
   create multiple binding cache entries. A new Binding Identification
   (BID) number is created for each binding the mobile node wants to
   create and sent in the binding update. The home agent that receives
   this Binding Update creates separate binding for each BID. The BID
   information is stored in the corresponding binding cache entry. The
   BID information can now be used to identify individual bindings. The
   same extensions can also be used in Binding Updates sent to the
   correspondent nodes.

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 [RFC-2119].

Terms used in this draft are defined in [RFC-3775], [RFC-3753] and
[RFC-4885]. In addition or in replacement of these, the following
terms are defined or redefined:

Binding Identification number (BID)

   The BID is an identification number used to distinguish multiple
   bindings registered by the mobile node. Assignment of distinct
   BIDs allows a mobile node to register multiple binding cache
   entries for a given home address. The BID MUST be unique for a
   binding to a specific care-of address for a given home address and
   care-of address pair. Zero and negative values MUST NOT be used.
   Each BID is generated and managed by a mobile node. The BID is
   stored in the Binding Update List and is sent by the mobile node
   in the Binding Update. A mobile node MAY change the value of a
   BID at any time according to its administrative policy, for
   instance to protect its privacy. An implementation must carefully
   assign the BID so as to keep using the same BID for the same
   binding even when the status of the binding is changed. More
   details can be found in Section 5.1.

Binding Identifier Mobility Option

   The Binding Identifier mobility option is used to carry the BID
   information.

Bulk Registration

   A mobile node can register multiple bindings at once by sending a
   single Binding Update. A mobile node can also replace some or all
   the bindings available at the home agent with the new bindings by
   using the bulk registration. Bulk registration is supported only
   for home registration (i.e. with the home agent) as explained in
   Section 5.4. A mobile node MUST NOT perform bulk registration
   mechanism described in this specification with a correspondent
   node.

3. **Protocol Overview**

   A new extension called the Binding identification number (BID) is
   introduced to distinguish between multiple bindings pertaining to the
   same home address. If a mobile node configures several IPv6 global
   addresses on one or more of its interfaces, it can register these
   addresses with its home agent as care-of addresses. If the mobile
   node wants to register multiple bindings, it MUST generate a BID for
   each care-of address and store the BID in the binding update list. A
   mobile node can manipulate each binding independently by using the
   BIDs. The mobile node then registers its care-of addresses by
   sending a Binding Update with a Binding Identifier mobility option.
   The BID is included in the Binding Identifier mobility option. After
   receiving the Binding Update with a Binding Identifier mobility
   option, the home agent MUST copy the BID from the Binding Identifier
   mobility option to the corresponding field in the binding cache
   entry. If there is an existing binding cache entry for the mobile
   node, and if the BID in the Binding Update does not match the one
   with the existing entry, the home agent MUST create a new binding
   cache entry for the new care-of address and BID. The mobile node can
   register multiple care-of addresses either independently in
   individual Binding Updates or multiple at once in a single Binding
   Update.

   If the mobile host wishes to register its binding with a
   correspondent node, it must perform return routability operations.
   This includes managing a Care-of Keygen token per care-of address and
   exchanging CoTi and CoT message with the correspondent node for each
   care-of address. The mobile node MAY use the same BID that it used
   with the home agent for a particular care-of address. For protocol
   simplicity, bulk registration to correspondent nodes is not supported
   in this document. This is because the Return Routability mechanism
   introduced in [RFC-3775] cannot be easily extended to verify multiple
   care-of addresses stored in a single Binding Update.

   Figure 1 illustrates the configuration where the mobile node obtains
   multiple care-of addresses at foreign links. The mobile node can
   utilize all the care-of addresses. In Figure 1, the home address of
   the mobile node (MN) is 2001:db8::EUI. The mobile node has 3
   different interfaces and possibly acquires care-of addresses 1-3
   (CoA1, CoA2, CoA3). The mobile node assigns BID1, BID2 and BID3 to
   each care-of address.

```
                    +----+
                    | CN |
                    +--+-+
                       |
                  +---+------+          +----+
            +------+ Internet |----------+ HA |
            |      +----+---+-+          +--+-+
         CoA2|         |   |                  |   Home Link
          +--+--+      |   |          ------+------
          |  MN +======+   |
          +--+--+ CoA1      |
         CoA3|              |
             +--------------+
```
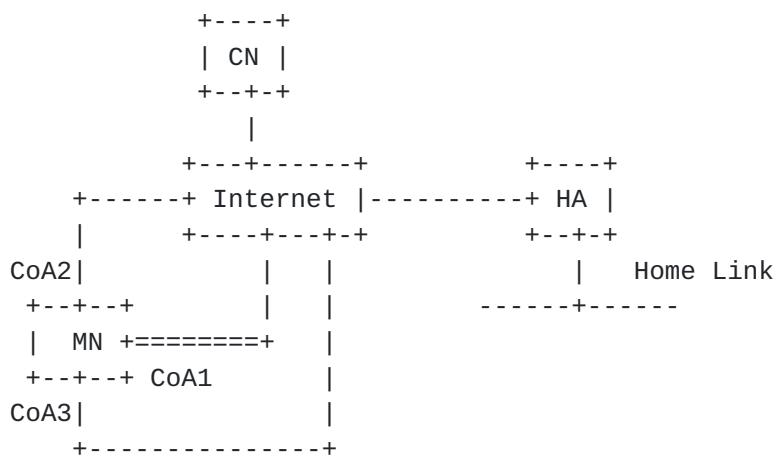
   Binding Cache Database:
       home agent's binding (Proxy neighbor advertisement is active)
             binding [2001:db8::EUI care-of address1 BID1]
             binding [2001:db8::EUI care-of address2 BID2]
             binding [2001:db8::EUI care-of address3 BID3]
       correspondent node's binding
             binding [2001:db8::EUI care-of address1 BID1]
             binding [2001:db8::EUI care-of address2 BID2]
             binding [2001:db8::EUI care-of address3 BID3]

            Figure 1: Multiple Care-of Address Registration

If the mobile node decides to act as a regular mobile node compliant
with [RFC-3775], it sends a Binding Update without any Binding
Identifier mobility options. The receiver of the Binding Update
deletes all the bindings registering with a BID and registers only a
single binding for the mobile node. Note that the mobile node can
continue using the BID even if it has only a single binding that is
active.

Binding cache lookup is done based on the home address and BID
information if a BID is available. This is different from RFC 3775,
where only the home address is used for binding cache lookup.
Binding cache lookup is operated for either protocol signaling and
data packets. For the protocol signaling such as a binding update,
BID should be always carried by a BID sub-option in a protocol
signaling. Therefore, a correspondent binding cache that matches the
specified BID MUST be found from the binding cache database. On the
other hand, for the data packets, no BID information is carried in a
packet. The binding cache lookup may involve policy or flow filters
to retrieve a correspondent BID per packet in cases where some policy
or flow filters are used to direct a certain packet or flow to a
particular care-of address. However, the binding cache lookup using
policy or flow filters is out of scope for this document. If no such

mechanism is available and no BID is found for a packet, a node can
lookup based on only the home address. It uses the first matched
binding or a binding in a round robin fashion. This is
implementation dependent and configurable on a node. In case the
binding cache lookup for data packets, using the combination of home
address and BID, does not return a valid binding cache entry, the
home agent MAY perform another lookup based on only the home address.

The mobile node may return to the home link through one of its
interfaces. There are two options possible for the mobile node when
its returns home. Section 5.6 describes the returning home
procedures in more detail.

1. The mobile node uses only the interface with which it attaches to
    the home link. This is illustrated in Figure 2. It de-registers
    all bindings with the home agent related to all care-of
    addresses. The interfaces still attached to the visited link(s)
    are no longer going to be receiving any encapsulated traffic from
    the home agent. On the other hand, the mobile node can continue
    communicating with the correspondent node from the other
    interfaces attached to foreign links by using route optimization.
    Even if the mobile node is attached to the home link, it can
    still send Binding Updates for other active care-of addresses
    (CoA1 and CoA2) to correspondent nodes. Since the correspondent
    node has bindings, packets are routed to each Care-of Addresses
    directly.

```
                    +----+
                    | CN |
                    +--+-+
                       |
              +---+------+          +----+
       +------+ Internet |----------+ HA |
       |      +----+-----+          +--+-+
    CoA2|          |                   |    Home Link
     +--+--+       |               --+---+------
     |  MN +=======+                  |
     +--+--+ CoA1                     |
        |                             |
        +-----------------------------+
```
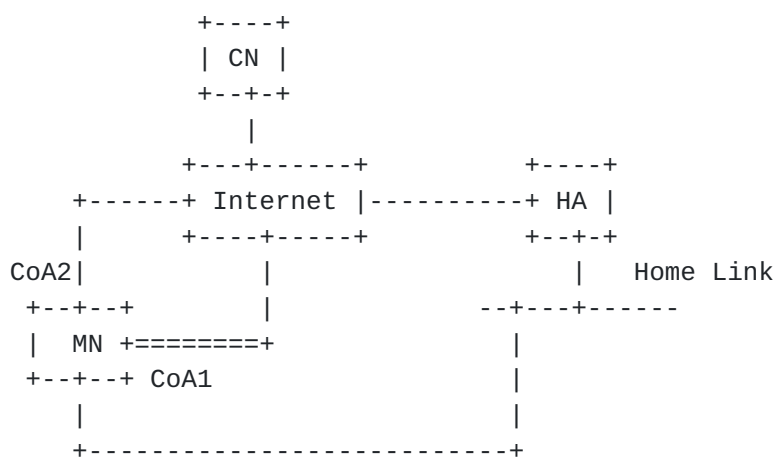
   Binding Cache Database:
      home agent's binding
            none
      correspondent node's binding
            binding [2001:db8::EUI care-of address1 BID1]
            binding [2001:db8::EUI care-of address2 BID2]

Figure 2: Using only Interface Attached to Home Link

2. The mobile node may simultaneously use both the interface
    attached to the home link and the interfaces still attached to
    the visited link(s) as shown in Figure 3. There are two possible
    topologies depending on whether the home agent is only router on
    the home link or not. The operation of Neighbor Discovery [RFC-
    4861] is different in the two topologies. More details can be
    found in Section 5.6.3. The home agent and the correspondent
    node have the binding entries listed in Figure 3 in their binding
    cache database in both topologies. The home agent also knows
    that the mobile node is attached to the home link. All the
    traffic from the Internet is intercepted by the home agent first
    and routed to either the interface attached to the home link or
    the one of the foreign links. How the home agent decides to
    route a particular flow to the interface attached to the home
    link or foreign link is out of scope in this document.

```
   Topology-a)
                    +----+
                    | CN |
                    +--+-+
                       |
                  +---+------+           +----+
            +------+ Internet |----------+ HA |
            |      +----+-----+          +--+-+
        CoA2|           |                   |   Home Link
         +--+--+        |              --+---+------
         | MN +========+              |
         +--+--+ CoA1                 |
            |                         |
            +--------------------------+


   Topology-b)
                    +----+
                    | CN |
                    +--+-+
                       |
                  +---+------+   Router    +----+
            +------+ Internet |-------R     | HA |
            |      +----+-----+       |     +--+-+
        CoA2|           |             |        |   Home Link
         +--+--+        |          --+-+-------+------
         | MN +========+            |
         +--+--+ CoA1               |
            |                       |
            +--------------------------+



      Binding Cache Database:
         home agent's binding
               binding [2001:db8::EUI  care-of address1  BID1]
               binding [2001:db8::EUI  care-of address2  BID2]
         correspondent node's binding
               binding [2001:db8::EUI  care-of address1  BID1]
               binding [2001:db8::EUI  care-of address2  BID2]


          Figure 3: Simultaneous Home and Visited Link Operation
```
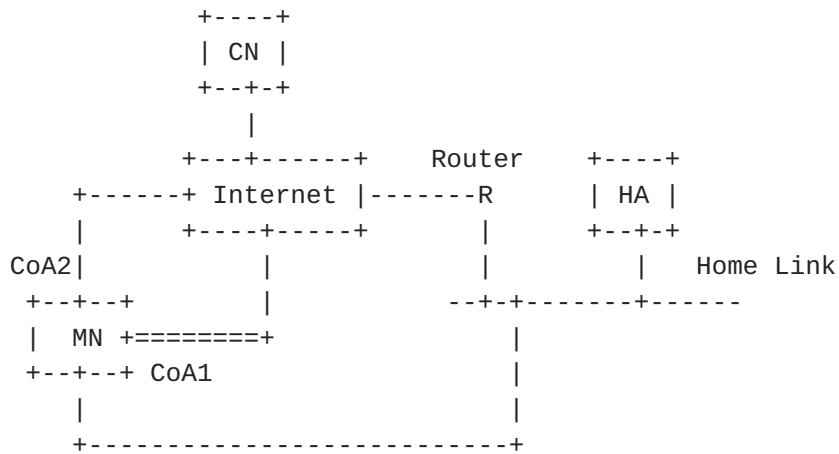
4. Mobile IPv6 Extensions

   This section summarizes the extensions to Mobile IPv6 necessary for
   manage multiple bindings.

4.1. Binding Cache Structure and Binding Update List

   The BID is required to be stored in the binding cache and binding
   update list structure.

   The sequence number value SHOULD be shared among all the binding
   update list entries related to binding updates sent to a particular
   home agent or correspondent node. Whenever a mobile node sends
   either individual or bulk binding update, the sequence number is
   incremented. On the other hand, if a mobile node manages an
   individual sequence value per binding update list, a mobile node
   SHOULD carefully select the sequence number value for the bulk
   binding update. This is because all the bulk-registered bindings use
   the same Sequence Number specified in the Binding Update. If each
   binding uses different sequence number, a mobile node MUST use the
   largest sequence number from the Binding Update list entries used for
   the bulk registration. If the mobile node cannot select a sequence
   number for all the bindings due to sequence number out of window, it
   MUST NOT use the bulk registration for the binding whose sequence
   number is out of window. A separate Binding Update should be sent
   for the binding.

4.2. Binding Identifier Mobility Option

   The Binding Identifier mobility option is included in the Binding
   Update, Binding Acknowledgement, Binding Refresh Request, and Care-of
   Test Init and Care-of Test message. The Binding Identifier Mobility
   Option has an alignment requirement of 2n if the Care-of Address
   field is not present. Otherwise, it has the alignment requirement of
   8n + 2.

```
                        1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
                               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                               | Type = TBD  |     Length    |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |      Binding ID (BID)      |     Status    |O|H| Reserved  |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-------------------------------+
   +                                                            +
   :            IPv4 or IPv6 care-of address (CoA)              :
   +                                                            +
   +------------------------------------------------------------+
```
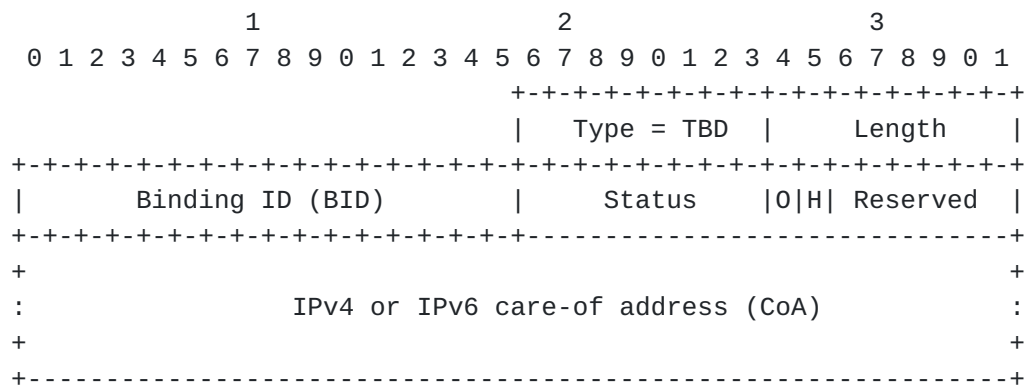
Figure 4: BID Mobility Option

Type

   Type value for Binding Identifier is TBD

Length

   8-bit unsigned integer. Length of the option, in octets,
   excluding the Type and Length fields. It MUST be set to either 4,
   12, or 20 depending on the care-of address field. When the
   care-of address is not carried by this option, the length value
   MUST be set to 4. If the IPv4 care-of address is stored in the
   care-of address field, the length MUST be 12. Otherwise, the
   Length value MUST be set to 20 for IPv6 care-of address.

Binding ID (BID)

   The BID which is assigned to the binding indicated by the care-of
   address in the Binding Update or the BID mobility option. The BID
   is a 16-bit unsigned integer. The value of zero is reserved and
   MUST NOT be used.

Status

   The Status field is an 8-bit unsigned integer. When the Binding
   Identifier mobility option is included in a Binding
   Acknowledgement, this field overwrites the status field in the
   Binding Acknowledgement. If this field is set to zero, the
   receiver ignores this field and uses the registration status
   stored in the Binding Acknowledgement message. The receiver MUST
   ignore this field if the Binding Identifier mobility option is not
   carried within either the Binding Acknowledgement or the Care-of
   Test messages. The possible status codes are the same as the
   status codes of Binding Acknowledgement. This Status field is
   also used to carry error information related to the care-of
   address test in the Care-of Test message.

Overwrite (O) flag

   When this flag is set, all the binding cache entries for a mobile
   node are replaced by new entries registering with this binding
   update message.

Simultaneous Home and Foreign Binding (H) flag

This flag indicates that the mobile node registers multiple
bindings to the home agent while is attached to the home link.
This flag is valid only for a Binding Update sent to the home
agent.

Reserved

5 bits Reserved field. The value MUST be initialized to zero by
the sender, and MUST be ignored by the receiver.

Care-of Address

If a Binding Identifier mobility option is included in a Binding
Update, either IPv4 or IPv6 care-of address for the corresponding
BID can be stored in this field. If no address is specified in
this field, the length of this field MUST be zero (i.e. not
appeared in the option). If the option is included in any other
messages than a Binding Update, the length of this field MUST be
also zero.

4.3. New Status Values for Binding Acknowledgement

New status values for the status field in a Binding Acknowledgement
are defined for handling the multiple Care-of Addresses registration:

MCOA NOTCOMPLETE (TBD less than 128)

In bulk registration, not all the binding identifier mobility
option are successfully registered. Some of them are rejected.
The error status value of the failed mobility option is
individually stored in the status field of the binding identifier
mobility option.

MCOA RETURNHOME WO/NDP (TBD less than 128)

When a mobile node returns home, it MUST NOT use NDP for the home
address on the home link. This is explained in more detail in
Section 5.6

MCOA MALFORMED (TBD more than 128)

Registration failed because Binding Identifier mobility option was
not formatted correctly.

MCOA BID CONFLICT (TBD more than 128)

The home agent cannot cache both a regular binding and a BID
extended binding simultaneously. It returns this status value
when the received binding conflicts with the existing binding
cache entry(ies).

MCOA PROHIBITED(TBD more than 128)

It implies the multiple care-of address registration is
administratively prohibited.

MCOA BULK REGISTRATION NOT SUPPORTED (TBD more than 128)

Bulk binding registration is not supported. Note that the bulk
registration is optional procedure and might not be available on a
home agent.

5. **Mobile Node Operation**

5.1. **Management of Care-of Address(es) and Binding Identifier(s)**

   There are two cases when a mobile node might acquire several care-of
   addresses. Note that a mixture of the two cases is also possible.

   1. A mobile node may be using several physical network interfaces
       and acquires a care-of address on each of its interfaces.

   2. A mobile node uses a single physical network interface, but
       receives advertisements for multiple prefixes on the link the
       interface is attached to. This will result in the mobile node
       configuring several global addresses on the interface from each
       of the announced prefixes.

   The difference between the above two cases is only in the number of
   physical network interfaces and therefore irrelevant in this
   document. What is of significance is the fact that the mobile node
   has several addresses it can use as care-of addresses.

   A mobile node assigns a BID to each care-of address when it wants to
   register them simultaneously with its home address. The BID MUST be
   unique for a given home address and care-of address pair. The value
   should be an integer between 1 and 65535. Zero value MUST NOT be
   used as BIDs. If a mobile node has only one care-of address, the
   assignment of a BID is not needed until it has multiple care-of
   addresses to register with, at which time all of the care-of
   addresses MUST be mapped to BIDs.

5.2. **Return Routability: Sending CoTI and Receiving CoT**

   When a mobile node wants to register multiple care-of address with a
   correspondent node, it MUST have the valid Care-of Keygen token per
   care-of address. The mobile node needs only one Home Keygen token
   for its home address.

   The mobile node MUST include a Binding Identifier mobility option in
   the Care-of Test Init message. It MUST NOT set any flags in the
   mobility option. The receiver (i.e. correspondent node) will
   calculate a care-of Keygen token as specified in [RFC-3775] and reply
   with a Care-of Test message, with the Binding Identifier mobility
   option as described in Section 6.2. When the mobile node receives
   the Care-of Test message, the message is verified as in [RFC-3775].
   If a Binding Identifier mobility option is not present in the CoT
   message in reply to the CoTI message that included a Binding
   Identifier mobility option, the mobile node must assume that the
   correspondent node does not support Multiple Care-of Address

registration. Thus, the mobile node MUST NOT use a Binding
Identifier mobility option in any future Binding Updates to that
correspondent node. The mobile node MAY skip re-sending regular CoTI
message and keep the received care-of Keygen token for the regular
Binding Update.

5.3. Binding Registration

For the multiple Care-of Addresses registration, the mobile node MUST
include a Binding Identifier mobility option(s) in the Binding Update
as shown in Figure 5. The BID is copied from a corresponding Binding
Update List entry to the BID field of the Binding Identifier mobility
option. When IPsec ESP is used for protecting the Binding Update,
the care-of address can be carried in the Care-of Address field of
the Binding Identifier mobility option. If this is done, the
alternate care-of address option MUST NOT be included in the Binding
Update. For binding registration to a correspondent node, the mobile
node MUST have both active Home and Care-of Keygen tokens for Kbm
(see Section 5.2.5 of [RFC-3775]) before sending the Binding Update.
The care-of Keygen tokens MUST be maintained for each care-of address
that the mobile node wants to register to the correspondent node.
The Binding Update to the correspondent node is protected by the
Binding Authorization Data mobility option that is placed after the
Binding Identifier mobility option.

```
            IPv6 header (src=CoA, dst=HA)
                IPv6 Home Address Option
                ESP Header*
                Mobility header
                    Binding Update
                   Mobility Options
                       Binding Identifier mobility option
                       Binding Authorization mobility option+
     (*) if necessary, for home registration
     (+) if necessary, for route optimization
```

Figure 5: Binding Update for Binding Registration

5.4. Bulk Registration

Bulk registration is an optimization for binding multiple care-of
addresses to a home address using a single Binding Update. This is
very useful if the mobile node, for instance, does not want to send a
lot of signaling messages through an interface where the bandwidth is
scarce. This document specifies bulk registration only for the
mobile node's home registration. A mobile node performing bulk
registration with a correspondent node is out of scope.

To use bulk registration, the mobile node includes a Binding
Identifier Mobility option for each BID and Care-of address pair it
wants to register in the same Binding Update message. This is shown
in Figure 6. The rest of the fields and options in the Binding
Update such as Lifetime, Sequence Number, and the flags in the
Binding Update are common across all care-of addresses. The
alternate care-of address option MUST NOT be used.

```
            IPv6 header (src=CoA, dst=HA)
                 IPv6 Home Address Option
                 ESP Header
                 Mobility header
                     Binding Update
                    Mobility Options
                       Binding Identifier mobility options (CoA)
```

Figure 6: Binding Update for Bulk Registration

If the mobile node wants to replace existing registered bindings on
the home agent with the bindings in the sent Binding Update, it sets
the 'O' flag. Section 6.3 describes this registration procedure in
detail.

5.5. Binding De-Registration

When a mobile node decides to delete all the bindings for its home
address, it sends a regular de-registration Binding Update with
lifetime set to zero as defined in [RFC-3775]. The Binding
Identifier mobility option is not required.

If a mobile node wants to delete a particular binding(s) from its
home agent and correspondent nodes, the mobile node sends a Binding
Update with lifetime set to zero and includes a Binding Identifier
mobility option(s) with the BID(s) it wants to de-register. The
receiver will remove only the care-of address(es) that match(es) the
specified BID(s). The care-of addresses field in each mobility
option SHOULD be omitted by the sender (i.e. the field does not
appear in the option) and MUST be ignored by the receiver. This is
because the receiver will remove the binding that matches the
specified BID.

5.6. Returning Home

The mobile node may return to the home link, by attaching to the home
link through one of its interfaces. When the mobile node wants to
return home, it should be configured with information on what
interface it needs to use. The mobile node may use only the
interface with which it is attached to the home link, only the

interfaces still attached to the visited link(s) or use both
interfaces attached to the home link and visited link(s)
simultaneously. The following describes each option in more detail.

5.6.1. Using only Interface attached to the Home Link

The mobile node returns home and de-registers all the bindings as
shown in Figure 2 and as defined in [RFC-3775]. De-registering all
the bindings is the same as binding de-registration from foreign link
described in Section 5.5. After the de-registration step, all the
packets routed by the home agent are only forwarded to the interface
attached to the home link, even if there are other active interfaces
attached to the visited link(s). While the mobile node de-registers
all the bindings from the home agent, it may continue registering
bindings for interface(s) attached to visited link(s) to the
correspondent node as shown in Figure 2.

5.6.2. Using only Interface attached to the Visited Link

The mobile node returns home in physically and shuts down the
interface attached to the home link. As a result, a mobile node does
not return home even though it attaches to the home link by one of
interfaces. Following procedures should be taken by the mobile node.
Before shutting down the interface, any binding for the care-of
address previously associated with the interface should be deleted.
To delete the binding cache entry, the mobile node SHOULD send a de-
registration Binding Update with the lifetime set to zero and include
the corresponding BID information. If the mobile node does not send
a de-registration Binding Update, the binding for the care-of address
previously assigned to the interface remains at the home agent until
its lifetime expires.

In this scenario, despite the fact that the mobile node is connected
to its home link, all of its traffic is sent and received via the
home agent and its foreign links.

5.6.3. Simultaneous Home and Visited Link Operation

[Problems of Simultaneous Home and Foreign Attachments]

The mobile node returns home and continues using all the interfaces
attached to both foreign and home links as shown in Figure 3. The
mobile node indicates this by setting the 'H' flag in the BID
mobility option as defined below. There are additional requirements
on the Returning Home procedures for possible Neighbor Discovery
states conflicts at the home link.

In [RFC-3775], the home agent intercepts packets meant for the mobile
node using the Proxy Neighbor Discovery [RFC-4861] while the mobile
node is away from the home link. When the mobile node returns home,
the home agent deletes the binding cache and stops proxying for the
home address so that a mobile node can configure its home address on
the interface attached to the home link. In this specification, a
mobile node may return home, configure the home address on the
interface attached to the home link, but still use the interfaces
attached to the foreign links. In this case, a possible conflict
arises when the both the home agent and the mobile node try to defend
the home address. If the home agent stops proxying for the home
address, the packets are always routed to the interface attached to
the home link and are never routed to the interfaces attached to the
visited links. It is required to avoid the conflict between the home
agent and the mobile node, while still allowing the simultaneous use
of home and foreign links. The following describes the mechanism for
achieving this.

[Overview and Approach]

In this specification, the home agent MUST intercept all the packets
meant for the mobile node and decide whether to send the traffic
directly to the home address on the link or tunnel to the care-of
address. The home agent intercepts all the packets even when the
mobile node is attached to the home link through one of its
interfaces. The home agent would make this decision based on the
type of flow. How to make this decision is out of scope in this
document.

Two scenarios are illustrated in Figure 3, depending on whether the
Home Agent is the only router at the home link or not. The
difference is on who defends the home address by (Proxy) Neighbor
Discovery on the home link.

1. Mobile node defends the home address by the regular Neighbor
    Discovery Protocol (illustrated as topology-a in Figure 3). The
    home agent is the only router on the home link. Therefore the
    home agent is capable of intercepting packets without relying on
    the proxy Neighbor Discovery protocol and the mobile node can
    manage the Neighbor Cache entry of the home address on the home
    link as a regular IPv6 node.

2. If there are other routers on the home link apart from the home
    agent, then it cannot be guaranteed that all packets meant for
    the mobile node are routed to the home agent. In this case, the
    mobile node MUST NOT operate Neighbor Discovery protocol for the
    home address on the home link. This allows the home agent to

keep using proxy neighbor discovery and thus it keeps receiving
all the packets sent to the mobile node's home address. If the
home agent, according to its local policy, needs to deliver
packets to the mobile node over the home link, an issue arises
with respect to how the home agent discovers the mobile node's
link local address. This specification uses Link-layer Address
(LLA) Option defined in [RFC-5268] in order to carry the mobile
node's link-layer address in the Binding Update. Likewise, the
mobile node would also know the link-layer address of the default
router address to send packets from the home link without
Neighbor Discovery. The link-layer address is used to transmit
packets from and to the mobile node on the home link. The
packets are transmitted without the Neighbor Discovery protocol
by constructing the link-layer header manually. This operation
is similar to Mobile IPv6 [RFC-3775] when a mobile node sends a
deregistration binding update to the home agent's link-layer
address in returning home operation.

[Sending Deregistration Binding Update]

o As soon as a mobile node returns home, it sends a de-registration
   Binding Update to the home agent from the interface attached to
   the home link.

o The mobile node MUST include the BID mobility option specifying
   the BID the mobile node had previously associated with the
   interface attached to the home link. The 'H' flag MUST be set in
   the BID mobility option. None of the care-of address MUST be sent
   in the Care-of Address field of the BID mobility option. When the
   'H' flag is set, the home agent recognizes that the mobile node
   wants to continue using interfaces attached to both home and
   visited links. Note that H flag MUST be set for all the binding
   updates sent from the mobile node (ex. Binding Update for the
   interface(s) attached to the foreign link(s)).

o The mobile node SHOULD include the Link-layer Address (LLA) Option
   [RFC-5268] to notify the mobile node's link-layer address to the
   home agent, too. The option code of the Link-layer Address (LLA)
   option MUST be set to '2' (Link-layer Address of the mobile node).
   This link-layer address is required for the home agent to send the
   Binding Acknowledgement and to forward the mobile node's packet.

o According to [RFC-3775], the mobile node MUST start responding to
   Neighbor Solicitation for its home address right after it sends
   the deregistration Binding Update to the home agent. However, in
   this specification, the mobile node MUST NOT respond to Neighbor
   Solicitation before receiving a Binding Acknowledgement, since the

home agent may continue proxying for the home address. If the
mobile node receives [MCOA RETURNHOME WO/NDP (TBD)] status value
in the received Binding Acknowledgment, it MUST NOT respond to
Neighbor Solicitation even after the Binding Acknowledgement.

[Sending Binding Acknowledgement]

o When the home agent sends the Binding Acknowledgement after
   successfully processing the binding de-registration, it MUST set
   the status value to either 0 [Binding Update Accepted] or to [MCOA
   RETURNHOME WO/NDP (TBD)] in the Status field of the Binding
   Acknowledgment depending on home agent configuration at the home
   link. The new values are:

   * Binding Update Accepted (0): NDP is permitted for the home
      address at the home link. This is regular returning home
      operation of [RFC-3775]

   * MCOA RETURNHOME WO/NDP (TBD): NDP is prohibited for the home
      address at the home link

   If the binding update is rejected, the appropriate error value
   MUST be set to the status field. In this case, the home agent
   operation is same as [RFC-3775].

o Only if the home agent is certainly the only router in the home
   link, it MAY turn off Neighbor Discovery for the requested home
   address and responds with the [Binding Update Accepted] status
   value to the mobile node. Since the mobile node will not reply to
   Neighbor Solicitation for the home address before receiving the
   Binding Acknowledgement, the home agent SHOULD use the link-layer
   address carried by the Link Layer Address option [RFC-5268] in the
   received Binding Update. After the completion of the binding
   deregistration, the mobile node starts regular Neighbor Discovery
   operations for the home address on the home link. The neighbor
   cache entry for the home address is created by the regular
   exchange of Neighbor Solicitation and Neighbor Advertisement.

o On the other hand, the home agent returns [MCOA RETURNHOME WO/NDP]
   value in the Status field of the BID mobility option. The home
   agent learns the mobile node's link-layer address by receiving the
   link-layer address option carried by the Binding Update. It
   stores the link-layer address as a neighbor cache entry for the
   mobile node so that it can send the packets to the mobile node's
   link-layer address.

o Note that the use of proxy Neighbor Discovery is easier way to
   intercept the mobile nodes' packets instead of IP routing in some
   deployment scenarios. Therefore, even if a home agent is the only
   router, it is an implementation and operational choice whether the
   home agent returns [Binding Update Accepted] or [MCOA RETURNHOME
   WO/NDP].

o If BID option is not included in the Binding Acknowledgement, the
   home agent might not recognize the simultaneous home and foreign
   attachment. The home agent might have processed the de-
   registration Binding Update as a regular de-registration as
   described in [RFC-3775] and deletes all the registered binding
   cache entries for the mobile node. Thus, the mobile node SHOULD
   stop using the interface attached to foreign link and use only the
   interface attached to the home link.

[Sending Packets from the Home Link]

o When the mobile node receives the Binding Acknowledgement with the
   status value 'Binding Update Accepted' and the BID option, it can
   configure its home address to the interface attached to the home
   link and start operating Neighbor Discovery for the home address
   on the home link. Packets can be transmitted from and to the
   mobile node as if the mobile node is a regular IPv6 node.

o If the mobile node receives the status [MCOA RETURNHOME WO/NDP] in
   the Binding Acknowledgement, it MUST NOT operate Neighbor
   Discovery for the home address. When the mobile node sends
   packets from the interface attached to the home link, it MUST
   learn the link-layer address of the next hop (i.e. default router
   of the mobile node). A mobile node learns the default router's
   link-layer address from a Source Link-Layer Address option in
   Router Advertisements. The mobile node sends packets directly to
   the default router's link-layer address. This is done by
   constructing the packet including link-layer header with the
   learned link-layer address of the default router. The home agent
   also forwards the packet to the mobile node on the home link by
   using the mobile node's link-layer address. The link-layer
   address SHOULD be cached when the home agent received the
   deregistration Binding Update message. Note that the default
   router MUST NOT cache the mobile node's link-layer address as a
   neighbor cache when it forwards the packet from the mobile node to
   the home agent.

[Leaving from the Home Link]

o When the mobile node detaches from the home link, it SHOULD
   immediately send a binding update for one of active care-of
   address with H flag unset. When the 'H' flag of BID option is
   unset in any Binding Update, the home agent stop forwarding the
   mobile node's packet to the home link.

o On the other hand, if the mobile node does not have any active
   care-of address to send a Binding Update and leaves the home link
   (i.e. the mobile node is completely disconnected), the home agent
   continues forwarding packets to the mobile node until the
   expiration of all the binding cache entries for the home address.
   Once all the bindings are expired, the mobile node is assumed to
   be disconnected completely from networks.

[Changing Behavior during the attachment to the home link]

If a mobile node decides to return home completely without any active
foreign link attachment, it simply sends a deregistration binding
update as described in Section 5.6.1. Once the home agent receives
such de-registration binding update, the home agent clears all the
binding and states for the mobile node.

If a mobile node decides to stop using the interface attached to the
home link, it simply sends a binding update from the one of active
care-of address. In the Binding Update, the mobile node should
include the BID option for the care-of address and unset the H flag
of BID option. The home agent clears the states of the mobile node
for the interface attached to the home link and stop forwarding the
packets to the mobile node on the home link.

5.7. Receiving Binding Acknowledgement

The verification of a Binding Acknowledgement is the same as Mobile
IPv6 (section 11.7.3 of [RFC-3775]). The operation for sending a
Binding Acknowledgement is described in Section 6.3.

If a mobile node includes a Binding Identifier mobility option in a
Binding Update with the 'A' flag set, a Binding Acknowledgement MUST
carry a Binding Identifier mobility option. If no such mobility
option is included in the Binding Acknowledgement in response to a
Binding Update for multiple care-of address registration, this
indicates that the originating node of the Binding Acknowledgement
does not support processing the Binding Identifier mobility option.
The mobile node MUST then stop multiple care-of address registration
with that node.

If a Binding Identifier mobility option is present in the received

Binding Acknowledgement, the mobile node checks the status field in
the option. If the status value in the Binding Identifier mobility
option is zero, the mobile node uses the value in the Status field of
the Binding Acknowledgement. Otherwise, it uses the value in the
Status field of the Binding Identifier mobility option.

If the status code is greater than or equal to 128, the mobile node
starts relevant operations according to the error code. Otherwise,
the mobile node assumes that the originator (home agent or
correspondent node) successfully registered the binding information
and BID for the mobile node.

o If the Status value is [MCOA PROHIBITED], the mobile node MUST
   stop registering multiple bindings to the node that sent the
   Binding Acknowledgement.

o If the Status value is [MCOA BULK REGISTRATION NOT SUPPORT], the
   mobile node SHOULD stop using bulk registrations with the node
   that sent the Binding Acknowledgement.

o If [MCOA MALFORMED] is specified, it indicates that the binding
   identifier mobility option is formatted wrongly.

o If [MCOA BID CONFLICT] is specified, the binding entry specified
   by the Binding Identifier mobility option is already registered as
   a regular binding. In such case, the mobile node SHOULD stop
   sending Binding Updates with BID, or SHOULD use the 'O' flag to
   reset all the registered bindings.

5.8. Receiving Binding Refresh Request

The verification of a Binding Refresh Request is the same as in
Mobile IPv6 (section 11.7.4 of [RFC-3775]). The operation of sending
a Binding Refresh Request is described in section Section 6.4.

If a mobile node receives a Binding Refresh Request with a Binding
Identifier mobility option, it indicates that the node sending the
Binding Refresh Request message is requesting the mobile node to send
a new Binding Update for the BID. The mobile node SHOULD then send a
Binding Update only for the respective binding. The mobile node MUST
include a Binding Identifier mobility option in the Binding Update.

5.9. Bootstrapping

When a mobile node bootstraps and registers multiple bindings for the
first time, it MUST set the 'O' flag in the Binding Identifier
mobility option. If old bindings still exists at the home agent, the
mobile node has no knowledge of which bindings still exist at the

home agent. This scenario happens when a mobile node reboots and
looses state regarding the registrations. If the 'O' flag is set,
all the bindings are replaced by the new binding(s). If the mobile
node receives the Binding Acknowledgement with the status code set to
135 [Sequence number out of window], it MUST retry sending a Binding
Update with the last accepted sequence number indicated in the
Binding Acknowledgement.

The 'O' flag can also be used in individual Binding Updates sent to
the correspondent nodes to override any existing binding cache
entries at the correspondent node.

[6](#). Home Agent and Correspondent Node Operation

[6.1](#). Searching Binding Cache with Binding Identifier

   If either a correspondent node or a home agent has multiple bindings
   for a mobile node in their binding cache database, it can use any of
   the bindings to communicate with the mobile node. This section
   explains how to retrieve the desired binding for the binding
   management. This document does not provide any mechanism to select
   the suitable binding for forwarding data packets.

   A node which is either a correspondent node or a home agent SHOULD
   use both the home address and the BID as the search key of the
   binding cache if it knows the corresponding BID (ex. when processing
   signaling messages). In the example below, if a node searches the
   binding with the home address and BID2, it gets binding2 for this
   mobile node.

                binding1 [2001:db8::EUI, care-of address1, BID1]
                binding2 [2001:db8::EUI, care-of address2, BID2]
                binding3 [2001:db8::EUI, care-of address3, BID3]

                    Figure 7: Searching the Binding Cache

   The node learns the BID when it receives a Binding Identifier
   mobility option. At that time, the node MUST look up its binding
   cache database with the home address and the BID retrieved from the
   Binding Update. If the node does not know the BID, it searches for a
   binding with only the home address. In such a case, the first
   matched binding is found. If the node does not desire to use
   multiple bindings for a mobile node, it can simply ignore the BID.

[6.2](#). Receiving CoTI and Sending CoT

   When a correspondent node receives a CoTI message which contains a
   Binding Identifier mobility option, it processes it as follows.

   First, the CoTI message is verified as specified in [[RFC-3775](#)]. The
   Binding Identifier mobility option is processed as follows:

   o If a correspondent node does not understand a Binding Identifier
      mobility option, it just ignores and skips processing the option.
      The calculation of a care-of Keygen token will thus be done
      without a BID value. The correspondent node returns a CoT message
      without a Binding Identifier mobility option. The mobile node
      knows whether the correspondent supports processing the Binding
      Identifier mobility option, by checking if the option is present
      in the CoT message.

o If either the 'C' or the 'O' flag is set in the Binding Identifier
   mobility option, the correspondent Node SHOULD NOT calculate a
   care-of Keygen token, but MUST include a Binding Identifier
   mobility option with status value set to [MCOA MALFORMED] in the
   Care-of Test message.

o Otherwise, the correspondent node MUST include a Binding
   Identifier mobility option with status value set to zero (success)
   in the Care-of Test message.

o The Care-of address field of each Binding Identifier mobility
   option, can be omitted, because the mobile node can identify the
   corresponding Binding Update list entry using the BID.

6.3. Processing Binding Update

If a Binding Update does not contain a Binding Identifier mobility
option, its processing is same as in [RFC-3775]. If the receiver
already has multiple bindings for the home address, it MUST replace
all the existing bindings by the received binding. As a result, the
receiver node MUST have only one binding cache entry for the mobile
node. If the Binding Update is for de-registration, the receiver
MUST delete all existing bindings from its Binding Cache.

If the Binding Update contains a Binding Identifier mobility
option(s), it is first validated according to section 9.5.1 of [RFC-
3775]. Then the receiver processes the Binding Identifier mobility
option(s) as described in the following steps.

o The length value is examined. The length value MUST be either 4,
   8, or 20 depending on the Care-of Address field. If the length is
   incorrect, the receiver MUST reject the Binding Update and returns
   the status value set to [MCOA MALFORMED].

o When the Length value is either 12 or 20, the care-of address MUST
   be present in the Binding Identifier mobility option. If the
   valid care-of address is not present, the receiver MUST reject the
   Binding Identifier mobility option and returns the status value
   set to [MCOA MALFORMED].

o When multiple Binding Identifier mobility options are present in
   the Binding Update, it is treated as bulk registration. If the
   receiving node is a correspondent node, it MUST reject the Binding
   Update and returns the status value in the binding acknowledgement
   set to [MCOA BULK REGISTRATION NOT SUPPORT]

o If the Lifetime field in the Binding Update is set to zero, the
   receiving node deletes the binding entry that corresponds to the

BID in the Binding Identifier mobility option. If the receiving
node does not have an appropriate binding for the BID, it MUST
reject the Binding Update and send a Binding Acknowledgement with
status set to 133 [not home agent for this mobile node].

o If the 'O' flag is set in the de-registering Binding Update, it is
   ignored. If the 'H' flag is set, the home agent stores a home
   address in the Care-of Address field of the binding cache entry.
   The home agent MUST follow the descriptions described in
   Section 5.6.

o If the Lifetime field is not set to zero, the receiving node
   registers a binding with the specified BID as a mobile node's
   binding. The Care-of address is obtained from the Binding Update
   packet as follows:

   * If the Length value of the Binding Identifier mobility option
      is 20, the care-of address is copied the IPv6 address from the
      care-of address field in the Binding Identifier mobility
      option. When the Length value is 12, the address MUST be the
      IPv4 valid address. Detail information can be found in
      Section 8.

   * If the Length value of the Binding Identifier mobility option
      is 4, the care-of address is copied from the source address
      field of the IPv6 header.

   * If the Length value of the Binding Identifier mobility option
      is 4 and an alternate care-of address is present, the care-of
      address is copied from the Alternate Care-of address mobility
      option.

o Once the care-of address(es) have been retrieved from the Binding
   Update, the receiving nodes creates new binding(s).

   * If only the 'O' flag is set in the Binding Identifier mobility
      option, the home agent removes all the existing bindings and
      registers the received bindings.

   * If the receiver has a regular binding which does not have BID
      for the mobile node, it must not process the binding update.
      The receiver should sent a binding acknowledgement with status
      set to [MCOA BID CONFLICT].

   * If the receiver already has a binding with the same BID but
      different care-of address, it MUST update the binding and
      respond with a Binding Acknowledgement with status set to 0
      [Binding Update accepted].

* If the receiver does not have a binding entry for the BID, it
  registers a new binding for the BID and responds with a Binding
  Acknowledgement with status set to 0 [Binding Update accepted].

If all the above operations are successfully completed, a Binding
Acknowledgement containing the Binding Identifier mobility options
MUST be sent to the mobile node. Whenever a Binding Acknowledgement
is sent, all the Binding Identifier mobility options stored in the
Binding Update MUST be copied to the Binding Acknowledgement except
the status field. The Care-of address field in each Binding
Identifier mobility option, however, can be omitted, because the
mobile node can match a corresponding binding update list entry using
the BID.

When a correspondent node sends a Binding Acknowledgement, the status
value MUST be always stored in the Status field of the Binding
Acknowledgement and the Status field of Binding Identifier mobility
option MUST be always set to zero.

When the home agent sends a Binding Acknowledgement, the status value
can be stored in the Status field of either a Binding Acknowledgement
or a Binding Identifier mobility option. If the status value is
specific to one of bindings in the bulk registration, the status
value MUST be stored in the Status field in the corresponding Binding
Identifier mobility option. In this case, [MCOA NOTCOMPLETE] MUST be
set to the Status field of the Binding Acknowledgement so that the
receiver can examine the Status field of each Binding Identifier
mobility option for further operations. Otherwise, the status field
of the Binding Identifier mobility option MUST be set to zero and the
home agent status field of the Binding Acknowledgement is used.

6.4. Sending Binding Refresh Request

When a node (home agent or correspondent node) sends a Binding
Refresh Request for a particular binding created with the BID, the
node SHOULD include the Binding Identifier mobility option in the
Binding Refresh Request. The node MAY include multiple Binding
Identifier mobility options if there are multiple bindings that need
to be refreshed.

6.5. Receiving Packets from Mobile Node

When a node receives packets with a Home Address destination option
from a mobile node, it MUST check that the care-of address that
appears in the source address field of the IPv6 header MUST be equal
to one of the care-of addresses in the binding cache entry. If no
binding is found, the packets MUST be discarded. The node MUST also
send a Binding Error message as specified in [RFC-3775]. This

verification MUST NOT be done for a Binding Update.

7. **Network Mobility Applicability**

   The binding management mechanisms are the same for a mobile host that
   uses Mobile IPv6 and for a mobile router that is using the NEMO Basic
   Support protocol [RFC-3963]. Therefore the extensions described in
   this document can also be used to support a mobile router with
   multiple care-of addresses. [RFC-4980] is a document for an analysis
   of NEMO multihoming.

8. **DSMIPv6 Applicability**

   Dual Stack Mobile IPv6 (DSMIPv6) [ID-DSMIPv6] extends Mobile IPv6 to
   register an IPv4 care-of address instead of the IPv6 care-of address
   when the mobile node is attached to an IPv4-only access network. It
   also allows the mobile node to acquire an IPv4 home address in
   addition to an IPv6 home address for use with IPv4-only correspondent
   nodes. This section describes how multiple care-of address
   registration works with IPv4 care-of and home addresses.

8.1. **IPv4 Care-of Address Registration**

   The mobile node can use the extensions described in the document to
   register multiple care-of addresses, even if some of the care-of
   addresses are IPv4 address.

   Bulk registration MUST NOT be used for the initial binding from an
   IPv4 care-of address. This is because, the Binding Update and
   binding acknowledgement exchange is used to detect NAT on the path
   between the mobile node and the home agent. So the mobile node needs
   to check for a NAT between each IPv4 care-of address and the home
   agent.

   The Binding Update MUST be sent to the IPv4 home agent address by
   using UDP and IPv4 headers as shown in Figure 8. It is similar to
   [ID-DSMIPv6] except that the IPv4 care-of address option MUST NOT be
   used when the BID mobility option is used.

```
              IPv4 header (src=V4ADDR, dst=HA_V4ADDR)
                 UDP Header
                   IPv6 header (src=V6HoA, dst=HAADDR)
                        ESP Header
                        Mobility header
                             -Binding Update
                            Mobility Options
                               - Binding Identifier (IPv4 CoA)


        Figure 8: Initial Binding Update for IPv4 Care-of Address
```

   If a NAT is not detected, the mobile node can update the IPv4 care-of
   address by using bulk registration. The mobile node can register the
   IPv4 care-of address along with other IPv4 and IPv6 care-of
   addresses. Figure 9 shows the Binding Update format when the mobile
   node sends a Binding Update from one of its IPv6 care-of addresses.
   If the mobile node sends a Binding Update from IPv4 care-of address,
   it MUST follow the format described in Figure 8. Note that the IPv4
   Care-of Address must be registered by non bulk Binding registration,
   whenever it is changed.

```
            IPv6 header (src=V6CoA, dst=HAADDR)
                  IPv6 Home Address Option
                  ESP Header
                  Mobility header
                       -Binding Update
                     Mobility Options
                          - Binding Identifier (IPv6/v4 CoA)
                          - Binding Identifier (IPv6/v4 CoA)
                          - ...
```

      Figure 9: Binding Bulk Registration for IPv4 care-of address

   If the home agent rejects the IPv4 care-of address, it MUST store the
   error code value in the Status field of the BID mobility option.

8.2. IPv4 HoA Management

   When the mobile node wants to configure an IPv4 home address in
   addition to the IPv6 home address, it can request for one using the
   IPv4 Home Address option in the Binding Update. If the home agent
   accepts the Binding Update, the mobile node can now register multiple
   care-of addresses for the IPv4 home address in addition to the IPv6
   home address. The same set of care-of addresses will be registered
   for both IPv6 and IPv4 home addresses. The mobile node cannot bind
   different set of care-of addresses to each home address.

   According to [ID-DSMIPv6], the home agent includes the IPv4 address
   acknowledgement option in the Binding Acknowledgement only if the
   mobile node had requested for an IPv4 home address in the
   corresponding Binding Update. The IPv4 address acknowledgement
   option MUST be present before any BID option. The status field of
   the IPv4 address acknowledgement option contains only the error code
   corresponding to the IPv4 home address management. The error values
   related to the IPv4 care-of address registration MUST be stored in
   the BID mobility option.

9. IPsec and IKEv2 interaction

   Mobile IPv6 [RFC-3775] and the NEMO protocol [RFC-3963] require the
   use of IPsec to protect signaling messages like Binding Updates,
   Binding Acknowledgements and return routability messages. IPsec may
   also be used protect all tunneled data traffic. The Mobile IPv6-
   IKEv2 specification [RFC-4877] specifies how IKEv2 can be used to
   setup the required IPsec security associations. The following
   assumptions were made in [RFC-3775], [RFC-3963] and [RFC-4877] with
   respect to the use of IKEv2 and IPsec.

   o There is only one primary care-of address per mobile node.

   o The primary care-of address is stored in the IPsec database for
      tunnel encapsulation and decapsulation.

   o When the home agent receives a packet from the mobile node, the
      source address is verified against the care-of address in the
      corresponding binding cache entry. If the packet is a reverse
      tunneled packet from the mobile node, the care-of address check is
      done against the source address on the outer IPv6 header. The
      reverse tunnel packet could either be a tunneled HoTi message or
      tunneled data traffic to the correspondent node.

   o The mobile node runs IKEv2 (or IKEv1) with the home agent using
      the care-of address. The IKE SA is based on the care-of address
      of the mobile node.

   The above assumptions may not be valid when multiple care-of
   addresses are used by the mobile node. In the following sections,
   the main issues with the use of multiple care-of address with IPsec
   are addressed.

9.1. Use of Care-of Address in the IKEv2 exchange

   For each home address the mobile node sets up security associations
   with the home agent, the mobile node must pick one care-of address
   and use that as the source address for all IKEv2 messages exchanged
   to create and maintain the IPsec security associations associated
   with the home address. The resultant IKEv2 security association is
   created based on this care-of address.

   If the mobile node needs to change the care-of address, it just sends
   a Binding Update with the care-of address it wants to use, with the
   corresponding Binding Identifier mobility option, and with the 'K'
   bit set. This will force the home agent to update the IKEv2 security
   association to use the new care-of address. If the 'K' bit is not
   supported on the mobile node or the home agent, the mobile node MUST

re-establish the IKEv2 security association with the new care-of
address. This will also result in new IPsec security associations
being setup for the home address.

9.2. Transport Mode IPsec protected messages

For Mobile IPv6 signaling message protected using IPsec in transport
mode, the use of a particular care-of address among multiple care-of
addresses does not matter for IPsec processing.

For Mobile Prefix Discovery messages, [RFC-3775] requires the home
agent to verify that the mobile node is using the care-of address
that is in the binding cache entry that corresponds to the mobile
node's home address. If a different address is used as the source
address, the message is silently dropped by the home agent. This
document requires the home agent implementation to process the
message as long as the source address is one of the care-of addresses
in the binding cache entry for the mobile node.

9.3. Tunnel Mode IPsec protected messages

The use of IPsec in tunnel mode with multiple care-of address
introduces a few issues that require changes to how the mobile node
and the home agent send and receive tunneled traffic. The route
optimization mechanism described in [RFC-3775] mandates the use of
IPsec protection in tunnel mode for the HoTi and HoT messages. The
mobile node and the home agent may also choose to protect all reverse
tunneled payload traffic with IPsec in tunnel mode. The following
sections address multiple care-of address support for these two types
of messages.

9.3.1. Tunneled HoTi and HoT messages

The mobile node MAY use the same care-of address for all HoTi
messages sent reverse tunneled through the home agent. The mobile
node may use the same care-of address irrespective of which
correspondent node the HoTi message is being sent. RFC 3775 requires
the home agent to verify that the mobile node is using the care-of
address that is in the binding cache entry, when it receives a
reverse tunneled HoTi message. If a different address is used as the
source address, the message is silently dropped by the home agent.
This document requires the home agent implementation to decapsulate
and forward the HoTi message as long as the source address is one of
the care-of addresses in the binding cache entry for the mobile node.

When the home agent tunnels a HoT message to the mobile node, the
care-of address used in the outer IPv6 header is not relevant to the
HoT message. So regular IPsec tunnel encapsulation with the care-of

address known to the IPsec implementation on the home agent is
sufficient.

9.3.2. Tunneled Payload Traffic

When the mobile sends and receives multiple traffic flows protected
by IPsec to different care-of addresses, the use of the correct
care-of address for each flow becomes important. Support for this
requires the following two considerations on the home agent.

o When the home agent receives a reverse tunneled payload message
   protected by IPsec in tunnel mode, it must check that the care-of
   address is one of the care-of addresses in the binding cache
   entry. According to RFC 4306, the IPsec implementation on the
   home agent does not check the source address on the outer IPv6
   header. Therefore the care-of address used in the reverse
   tunneled traffic can be different from the care-of address used as
   the source address in the IKEv2 exchange. However, the Mobile
   IPv6 stack on the home agent MUST verify that the source address
   is one of the care-of addresses registered by the mobile node
   before decapsulating and forwarding the payload traffic towards
   the correspondent node.

o For tunneled IPsec traffic from the home agent to the mobile node,
   The IPsec implementation on the home agent may not be aware of
   which care-of address to use when performing IPsec tunnel
   encapsulation. The Mobile IP stack on the home agent must specify
   the tunnel end point for the IPsec tunnel. This may require tight
   integration between the IPsec and Mobile IP implementations on the
   home agent.

10. Security Considerations

   The security considerations for securing the Binding Update and
   binding acknowledgement messages with multiple care-of address are
   very similar to the security considerations for securing the Binding
   Update and binding acknowledgement. Please see [RFC-3775] for more
   information. The Binding Update and binding acknowledgement messages
   with multiple care-of addresses MUST be protected using IPsec as show
   in Section 9. Additional security considerations are described
   below.

   With simultaneous binding support, it is possible for a malicious
   mobile node to successfully bind a number of victims' addresses as
   valid care-of addresses for the mobile node with its home agent.
   Once these addresses have been bound, the malicious mobile node can
   perform a re-direction attack by instructing the home agent (e.g.
   setting filtering rules to direct a large file transfer) to tunnel
   packets to the victims' addresses. Such risk is highlighted in [ID-
   MIP6ANALYSIS]. These attacks are possible because the care-of
   addresses sent by the mobile node in the Binding Update messages are
   not verified by home agent, i.e., the home agent does not check if
   the mobile node is at the care-of address it is claiming to be. The
   security model for Mobile IPv6 assumes that there is a trust
   relationship between the mobile node and its home agent. Any
   malicious attack by the mobile node is traceable by the home agent.
   This acts as a deterrent for the mobile node to launch such attacks.

   Although such risk exists in Mobile IPv6, the risk level is escalated
   when simultaneous multiple care-of address bindings are performed.
   In Mobile IPv6, a mobile node can only have a single care-of address
   binding per home address at a given time. However, for simultaneous
   multiple care-of address bindings, a mobile node can have more than
   one care-of address binding per home address at a given time. This
   implies that a mobile node using simultaneous binding support can
   effectively bind more than a single victim's address. Another
   difference is the degree of risk involved. In the single care-of
   address binding case, once the re-direction attack is initiated, a
   malicious mobile node would be unable to use its home address for
   communications (such as to receive control packets pertaining to the
   file transfer). However, in the simultaneous binding support case, a
   malicious mobile node could bind a valid care-of address in addition
   to multiple victims addresses. This valid care-of address could then
   be used by the malicious mobile node to set up flow filtering rules
   at its home agent, thereby controlling and/or launching new re-
   direction attacks.

   Thus, in view of such risks, it is advisable for a home agent to
   employ some form of care-of address verification mechanism before

using the care-of addresses as a valid routing path to a mobile node.
Solutions related to this are described in [ID-COAVERIFY].

11. IANA Considerations

The following Extension Types MUST be assigned by IANA:

o Binding Identifier mobility option type: This must be assigned
   from the same space as mobility option in [RFC-3775].

o New Successful Status of Binding Acknowledgement: This status code
   must be assigned from the same space as binding acknowledgement
   status codes in [RFC-3775].

   * MCOA NOTCOMPLETE (TBD)

   * MCOA RETURNHOME WO/NDP (TBD)

o New Unsuccessful Status of Binding Acknowledgement: These status
   codes must also be assigned from the same space as binding
   acknowledgement status codes in [RFC-3775].

   * MCOA MALFORMED (TBD)

   * MCOA BID CONFLICT (TBD)

   * MCOA PROHIBITED(TBD)

   * MCOA BULK REGISTRATION NOT SUPPORTED (TBD)

12. Acknowledgements

The authors would like to special thank George Tsirtsis for thorough review and suggestions. The authors would also like to thank Masafumi Aramoto, Keigo Aso, Julien Charbon, Tero Kauppinen, Benjamin Lim, Martti Kuparinen, Romain Kuntz, Heikki Mahkonen, Nicolas Montavont, Chan-Wah Ng for their discussions and inputs. Thanks to Susumu Koshiba, Hiroki Matutani, Koshiro Mitsuya, Koji Okada, Keisuke Uehara, Masafumi Watari and Jun Murai for earlier work on this subject.

13. References

13.1. Normative References

[RFC-2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

[RFC-4861] Narten, T., Nordmark, E., W. Simpson, and H. Soliman, "Neighbor Discovery for IP Version 6 (IPv6)", RFC 4861, September 2007..

[RFC-3775] Johnson, D., Perkins, C., and J. Arkko, "Mobility Support in IPv6", RFC 3775, June 2004.

[RFC-3963] Devarapalli, V., Wakikawa, R., Petrescu, A., and P. Thubert, "Network Mobility (NEMO) Basic Support Protocol", RFC 3963, January 2005.

[RFC-4877] Devarapalli, V. and F. Dupont, "Mobile IPv6 Operation with IKEv2 and the revised IPsec Architecture", RFC 4877, April 2007.

13.2. Informative References

[ID-MOTIVATION] Ernst, T., Montavont, N., Wakikawa, R., Ng, C., and K. Kuladinithi, "Motivations and Scenarios for Using Multiple Interfaces and Global Addresses", draft-ietf-monami6-multihoming-motivation-scenario-03 (work in progress), May 2008.

[RFC-4980] Ng, C., Paik, Ernst, and C. Bagnulo, "Analysis of Multihoming in Network Mobility Support", RFC 4980, October 2007.

[ID-MIP6ANALYSIS] Montavont, N., Wakikawa, R., Ernst, T., Ng, C., and K. Kuladinithi, "Analysis of Multihoming in Mobile IPv6", draft-ietf-monami6-mipv6-analysis-05 (Work in progress), May 2008.

[RFC-3753] Manner, J. and M. Kojo, "Mobility Related Terminology", RFC 3753, June 2004.

[RFC-4885] Ernst, T. and H. Lach, "Network Mobility Support Terminology", RFC 4885, July 2007.

[ID-DSMIPv6] Soliman, H., "Mobile IPv6 support for dual stack Hosts and Routers (DSMIPv6)", draft-ietf-mext-nemo-v4traversal-05 (work in progress), July 2008.

[ID-COAVERIFY] Lim, B., C. NG and K. Aso, "Verification of Care-of Addresses in Multiple Bindings Registration", draft-lim-mext-multiple-coa-verify-02 (work in progress), July 2008.

[RFC-5268] R. Koodli, "Mobile IPv6 Fast Handovers", RFC 5268, June 2008.

Authors' Addresses

    Ryuji Wakikawa
    Toyota ITC / Keio University
    6-6-20 Akasaka, Minato-ku
    Tokyo   107-0052
    Japan

    Phone: +81-3-5561-8276
    Fax: +81-3-5561-8292
    Email: ryuji@jp.toyota-itc.com

    Vijay Devarapalli
    Wichorus
    3590 North First St
    San Jose, CA   95134
    USA

    Email: vijay@wichorus.com

    Thierry Ernst
    INRIA
    INRIA Rocquencourt
    Domaine de Voluceau B.P. 105
    Le Chesnay,   78153
    France

    Phone: +33-1-39-63-59-30
    Fax: +33-1-39-63-54-91
    Email: thierry.ernst@inria.fr
    URI: http://www.nautilus6.org/~thierry

    Kenichi Nagami
    INTEC NetCore Inc.
    1-3-3, Shin-suna
    Koto-ku, Tokyo   135-0075
    Japan

    Phone: +81-3-5565-5069
    Fax: +81-3-5565-5094
    Email: nagami@inetcore.com

Full Copyright Statement

Intellectual Property

Acknowledgment