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Multiple Care-of Addresses Registration
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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.

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1. Introduction

   A mobile node may use various types of network interfaces to obtain
   durable and wide area network connectivity. This has 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] for 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 a 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 to or as a 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 BIDs assigned to a same
   home address must not be duplicated at a time. Zero value is
   reserved for future extension. 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 5.3. 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 as
   described in [[RFC-3775](#)]. This includes managing a Care-of Keygen
   token per care-of address and exchanging Care-of Test Init and
   Care-of Test 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|               |
         +---------------+
```
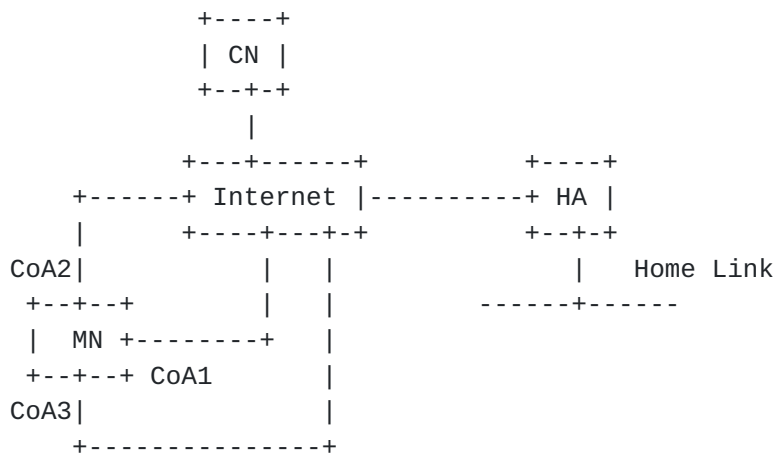
     Binding Cache Database:
         home agent's binding (Proxy neighbor advertisement is active)
              binding [2001:db8::EUI BID1 care-of address1]
              binding [2001:db8::EUI BID2 care-of address2]
              binding [2001:db8::EUI BID3 care-of address3]
         correspondent node's binding
              binding [2001:db8::EUI BID1 care-of address1]
              binding [2001:db8::EUI BID2 care-of address2]
              binding [2001:db8::EUI BID3 care-of address3]

              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
SHOULD use the binding which was last verified by receiving data
packets or signaling from the mobile 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
SHOULD perform the lookup based on only the home address as described
in [RFC-3775].

In any case, to avoid problems with upper layer protocols and TCP in
particular, a single packet flow as identified by the 5-tuple SHOULD
only be sent to a single care-of address at a time.

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 and Section 5.5.1 describe 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                    |
           |                            |
          +---------------------------+
```
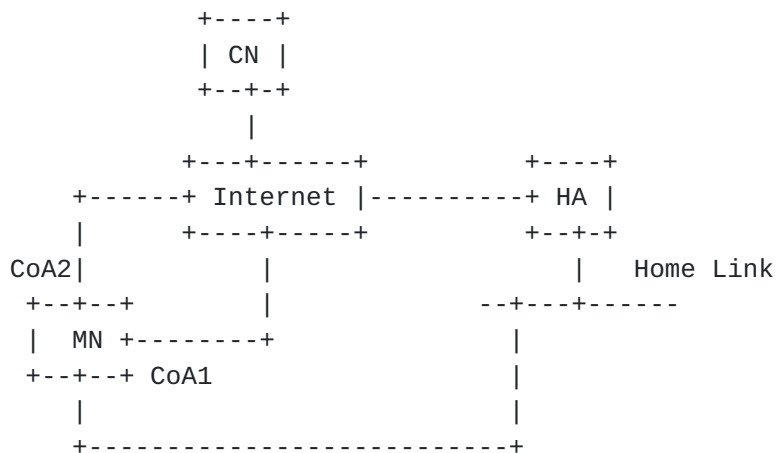
```
      Binding Cache Database:
         home agent's binding
               none
         correspondent node's binding
               binding [2001:db8::EUI  BID1 care-of address1]
               binding [2001:db8::EUI  BID2 care-of address2]
```

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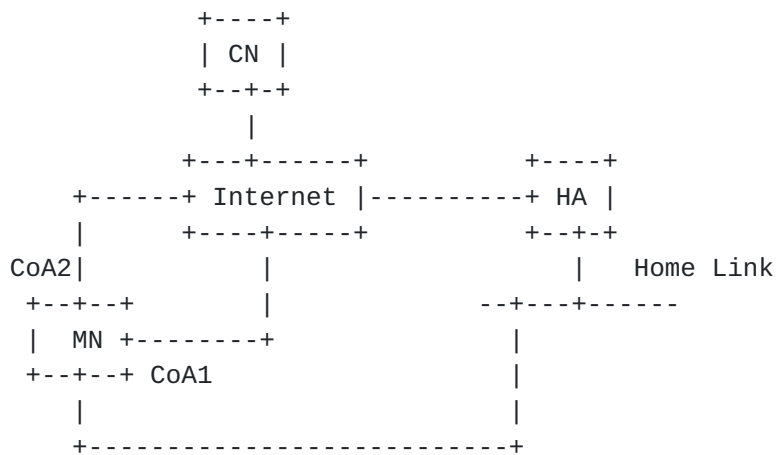
        Binding Cache Database:
           home agent's binding
                 binding [2001:db8::EUI BID1 care-of address1]
                 binding [2001:db8::EUI BID2 care-of address2]
           correspondent node's binding
                 binding [2001:db8::EUI BID1 care-of address1]
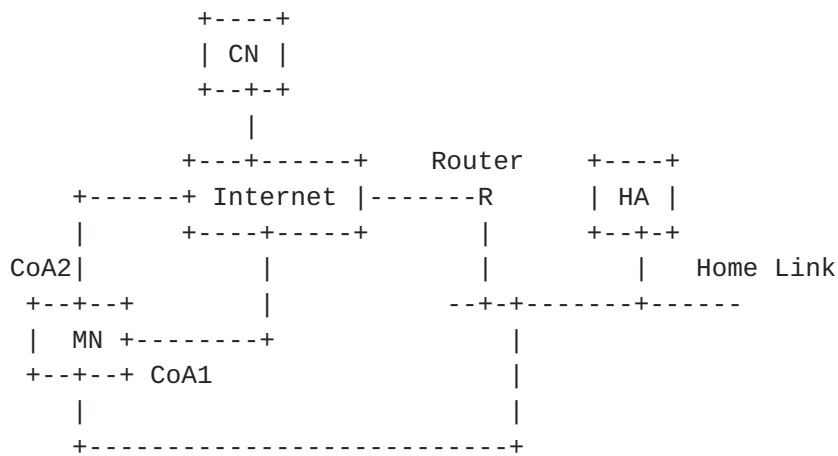   binding [2001:db8::EUI BID2 care-of address2]

         Figure 3: Simultaneous Home and Visited Link Operation

   This specification keeps backwards compatibility with [RFC-3775]. If
   a receiver (either home agent or correspondent node) does not support
   this specification, it does not understand the binding identifier
   mobility option. The receiver skip the unknown mobility option (i.e.
   Binding Identifier mobility option) and process the Binding Update as
   defined in [RFC-3775]. In order to keep the backward compatibility

   with [RFC-3775], when a mobile node sends a Binding Update message
   with extensions described in this document, the receiver needs to
   reflect the Binding Identifier mobility option in the Binding
   Acknowledgement. If the mobile node finds no Binding Identifier
   mobility options in the received Binding Acknowledgement, it assumes
   the other end node does not support this specification. In such
   case, the mobile node needs to fall back to the legacy RFC-3775
   compliant mobile node. If it is the home registration, the mobile
   node MAY try to discover another home agent supporting Binding
   Identifier mobility option for the home registration.

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 MUST 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 an individual or a bulk Binding Update, the sequence number is incremented. When a home agent receives an individual Binding Update, it should update the sequence number for all the bindings for a particular mobile node with the sequence number in the received Binding Update.

4.2. Binding Update Message

This specification extends the Binding Update message with a new flag. The flag is shown and described below.

```
                              +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                              |          Sequence #           |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |A|H|L|K|M|R|P|F|T|O| Reserved  |           Lifetime            |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                                                               |
     .                                                               .
     .                        Mobility options                      .
     .                                                               .
     |                                                               |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
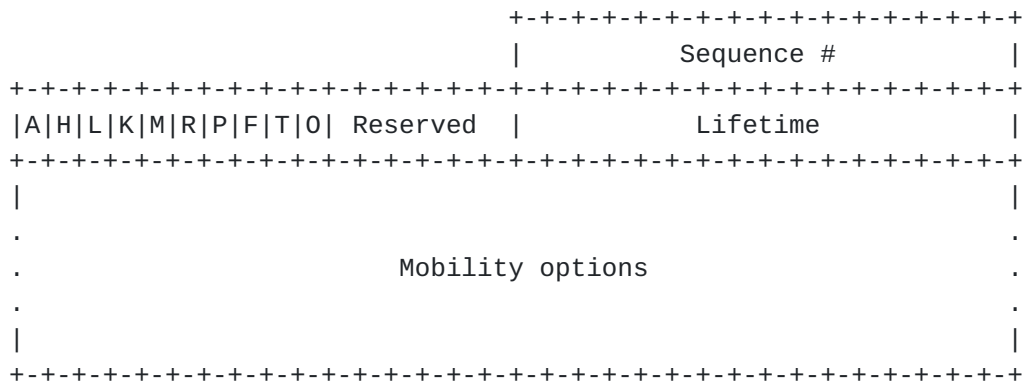
Figure 4: Binding Update message

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. This flag is only used when BID Mobility Option is carried with Binding Update.

Reserved

   6 bits Reserved field.

4.3. 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    |H|   Reserved  |
       +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-------------------------------+
       +                                                              +
       :               IPv4 or IPv6 care-of address (CoA)             :
       +                                                              +
       +--------------------------------------------------------------+
```
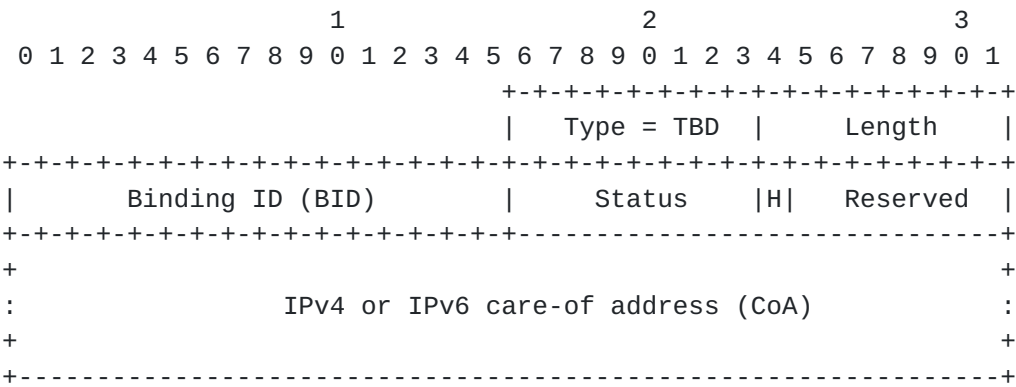
                       Figure 5: BID Mobility Option

   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,
      8, 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 8. 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 Binding Identifier 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 only for this BID. 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.

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

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

Care-of Address

   If a Binding Identifier mobility option is included in a Binding
   Update for the home registration, either IPv4 or IPv6 care-of
   address for the corresponding BID can be stored in this field.
   For the binding registration to correspondent nodes (i.e. route
   optimization), only IPv6 care-of address 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.

4.4. 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
options were successfully registered. Some of them were 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 Neighbor
Discovery Protocol (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. This value is used in the following
cases.

*   when the wrong length value is specified (neither 4, 8 nor 20)
    in the length field of the Binding Identifier mobility option.

*   when a unicast routable address is not specified in the care-of
    address field of the Binding Identifier mobility option.

*   when a care-of address is not appeared in the care-of address
    field of the Binding Identifier mobility option stored in an
    IPsec ESP protected Binding Update.

MCOA NON-MCOA BINDING EXISTS (TBD more than 128)

It indicates that a bootstrapping multiple care-of address
registration was performed without the 'O' flag set.

MCOA UNKOWN COA(TBD more than 128)

It indicates that a Binding Identifier Mobility Option did not
include a Care-of address field and the receiver has no record for
the Binding ID indicated in the same option.

MCOA PROHIBITED(TBD more than 128)

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

MCOA BULK REGISTRATION PROHIBITED(TBD more than 128)

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

MCOA SIMULTANEOUS HOME AND FOREIGN PROHIBITED (TBD more than 128)

Simultaneous home and foreign attachment is neither supported nor permitted.

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. A mixture of the two cases is also possible. Note that a
   mobile node can use BID regardless of the number of interfaces and
   care-of addresses. Whether a mobile node uses BID or not is
   determined by a local configuration.

   1. A mobile node is 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. The value is an integer between 1
   and 65535. Zero value SHOULD 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.

   When a mobile node registers a given BID for the first time it MUST
   include the care of address field in the Binding Identifier mobility
   option. For any subsequent registrations that either re-register or
   de-register the same BID, the MN SHOULD NOT include the care of
   address field in the Binding Identifier mobility option.

5.2. 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 6.

   When IPsec ESP is used for protecting the Binding Update, a care-of
   address MUST be carried in an alternate care-of address mobility
   option as described in [RFC-4877]. However, in this specification,
   the care-of address MUST be carried in the Care-of Address field of

the Binding Identifier mobility option. In order to save bits of the
Binding Update, the alternate care-of address option MUST NOT be
included.

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=Care-of Address, dst=Home Agent Address)
                    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 6: Binding Update for Binding Registration

If the mobile node wants to replace existing registered bindings on
the home agent with the single binding in the sent Binding Update, it
sets the 'O' flag. It the 'O' flag is not set then the binding will
be added to existing bindings in the home agent. The single binding
will be registered with the assigned BID. Section 6.2 describes this
registration procedure in detail.

5.3. 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 it wants to register in the
same Binding Update message. As with single registrations (see
Section 5.1), the care of address field is included for BID
registered for the first time. This is shown in Figure 7. 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.

```
            IPv6 header (src=Care-of Address, dst=Home Agent Address)
                IPv6 Home Address Option
                ESP Header
                Mobility header
                    Binding Update
                   Mobility Options
                      Binding Identifier1 (including Care-of Address)
                      Binding Identifier2 (including Care-of Address)
                      Binding Identifier3 (no Care-of Address)
                      Binding IdentifierN (no Care-of Address)

                           :
```

Figure 7: Binding Update for Bulk Registration

As with regular registrations, if the mobile node wants to replace
existing registered bindings on the home agent with the multiple
bindings in the sent Binding Update, it sets the 'O' flag in the
Binding Update, otherwise the bindings are added to the existing
bindings in the home agent.

5.4. 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). Since de-registration attempts to remove a BID
that already exists, the care-of addresses field in each binding
identifier option can be omitted by the sender as defined in
Section 5.1.

5.5. Returning Home: Using Single Interface

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.

5.5.1. 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]. 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.

5.5.2. Using only Interface attached to the Visited Link

   The mobile node returns home physically but 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. Before shutting down the interface, any binding for the
   care-of address previously associated with the interface should be
   deleted as defined in .

   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. Returning Home: Simultaneous Home and Visited Link Operation

5.6.1. 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.

   In [RFC-3775], the home agent intercepts packets meant for the mobile
   node using 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.

5.6.2. Overview and Approach

   The home agent MUST intercept all the packets meant for the mobile
   node whether the mobile node is attached to the home link or not and
   decide whether to send the traffic directly to the home address on
   the link or tunnel to the care-of address.

   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. However, there is one limitation of
       this scenario. If a correspondent node is located at the home
       link, the home agent may not intercept the packets destined to
       the mobile node. These packets are routed only via the home
       link, but this is the most optimal path for the mobile node to
       communicate with nodes on the home link.

   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 the 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 the Mobility Header
       Link-layer Address 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 the operation for returning home.

5.6.3. Home Binding Support

   When the home binding is used, the mobile node MUST send a
   registering binding update with a Binding Identifier mobility option
   whith H flag set. The lifetime MUST be set to a non-zero lifetime of
   the home binding, and the care-of address MUST be set to the home
   address.

   The mobile node SHOULD include the Mobility Header Link-layer Address
   Option [RFC-5268] to notify the mobile node's link-layer address to
   the home agent, too. The option code of the Mobility Header Link-
   layer Address 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.

   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.

   The management of the home binding is same as the binding management
   described in this specification. The home binding can be included in
   a bulk binding registration (Section 5.3). The MN SHOULD refresh the
   lifetime of the home binding by sending appropriate Binding Updates
   as with any other binding.

5.6.4. 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 a 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 in the
neighbor cache when it forwards the packet from the mobile node to
the home agent.

5.6.5. Leaving from the Home Link

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
packets to 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 6.2.

If a mobile node includes a Binding Identifier mobility option in a
Binding Update with the 'A' flag set, a Binding Acknowledgement
SHOULD carry a Binding Identifier mobility option. According to
[RFC-3775], the receiver of the Binding Update ignores unknown
mobility options and processes the Binding Update without the unknown
mobility option. Therefore, 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 regardless of
status value. In such case, the receiver of the Binding Update may
create a regular binding. The mobile node then SHOULD no longer
attempt multiple care-of address registration with that node. If
this occurs with home registration the mobile node MAY attempt to
discover another home agent supporting Binding Identifier mobility
option for the home registration.

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 with the node that sent the Binding Acknowledgement.

o If the Status value is [MCOA BULK REGISTRATION NOT SUPPORT], the mobile node needs to stop using bulk registrations with the node that sent the Binding Acknowledgement. It should assume that none of the attempted registrations were successful.

o If [MCOA MALFORMED] is specified, it indicates that the binding identifier mobility option is formatted wrongly presumably due to a programming error or major packet corruption. .

o If [MCOA NON-MCOA BINDING EXISTS] is specified, it means that there is non-MCoA binding entry in the receiver. The mobile node MUST set 'O' flag so that all the registered bindings are replced by an MCoA registration as described in Section 5.9.

o If [MCOA UNKNOWN COA] is specified, it means that the mobile node sent a binding identifier mobility option without a care-off address field but the receiver could not find an entry for the BID indicated. If the mobile node is trying to deregister a BID, it NEED NOT do anything further. If the mobile node is trying to refresh a binding it SHOULD send a binding identifier mobility option including the care-of address field.

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 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 at least for the respective binding, as described in Section 5.2 and Section 5.3.

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 Update message.
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 loses state regarding
the registrations. If the 'O' flag is set, all the bindings are
replaced by the new binding(s).

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 (example: 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 8: 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. Processing Binding Update

If a Binding Update does not contain a Binding Identifier mobility
option, its processing is the same as in [RFC-3775]. If the receiver
already has multiple bindings for the home address, it MUST replace
all the existing bindings with the received binding. If the [RFC-
3775] 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 8 or 20, the care-of address MUST
   be present in the Binding Identifier mobility option. If the
   unicast routable address [RFC-3775] is not present in the care-of
   address field, 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 8, the address MUST be the IPv4 valid
      address. How to obtain an IPv4 care-of address is described in
      Section 8.

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

   * If the 'O' flag is set in the Binding Update, the home agent
      removes all the existing bindings and registers the received

          binding(s).

     * If the 'O' flag is unset in the Binding Update and 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
        NON-MCOA BINDING EXISTS].

     * 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, MAY 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, the Status field of the
   Binding Acknowledgement MUST be set to [MCOA NOTCOMPLETE], 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.

6.3. Sending Binding Acknowledgement for home link registration

   The operations described in this section are related to the returning
   home using simultaneous use of home and foreign links.

o When the home agent sends the Binding Acknowledgement after
   successfully processing the home binding 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): Neighbor Discovery Protocol is
      permitted for the home address at the home link. This is
      regular returning home operation of [RFC-3775]

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

   The respective Binding Identifier mobility options need to be
   included in the Binding Acknowledgement.

o If the Binding Update is rejected, the appropriate error value
   MUST be set in the status field. In this case, the home agent
   operation is the 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 Mobility Header Link-Layer Address option
   [RFC-5268] in the received Binding Update. After the completion
   of the home binding registration, 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 Binding Identifier mobility
   option. The home agent learns the mobile node's link-layer
   address by receiving the Mobility Header 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 an 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 home registration. The home
   agent might have processed the home 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.

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 the 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
   registration 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 9. 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)
          *V4ADDR, HA_V4ADDR, V6HOA, HAADDR are defined in [ID-DSMIPv6]
```

         Figure 9: 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 10 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 9. Note that the IPv4
   Care-of Address must be registered by non bulk Binding registration,

whenever it is changed.

As shown in Figure 9, IPv4 care-of address will be appeared in
Binding Identifier mobility option. The IPv4 care-of address
mobility option defined in [ID-DSMIP6] MUST always be omitted. The
receiver of the Binding Update message for an IPv4 care-of address
MUST treat the IPv4 address stored in the Binding Identifier mobility
option as the one in the IPv4 care-of address mobility option of [ID-
DSMIP6]. If the IPv4 address in the Binding Identifier mobility
option is different from one in the source address field in the IPv4
header of the Binding Update (i.e. V4ADDR in Figure 9), the source
address is used as an IPv4 care-of address. Otherwise, the IPv4
address in the Binding Identifier mobility option is used as an IPv4
care-of address.

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

       Figure 10: Binding Bulk Registration for IPv4 care-of address

When the home agent returns a Binding Acknowledgement for the IPv4
care-of address registration, it SHOULD NOT use the IPv4 address
Acknowledgement mobility option and SHOULD use only the Binding
Identifier mobility option. The registration status for the IPv4
Care-of address is stored in the Status field of the Binding
Identifier mobility option. However, if the home agent needs to
store the status value specially defined for the IPv4 address
Acknowledgement mobility option, it MUST store the status value in
the IPv4 address Acknowledgement mobility option and MUST NOT store
it in Binding Identifier mobility option. In such case, the home
agent MUST include both the IPv4 address Acknowledgement mobility
option and Binding Identifier mobility option.

8.2. IPv4 Home Address 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 mobile node MUST always use the IPv4 home address

   mobility option for any purposes of the IPv4 home address management.
   The same set of care-of addresses will be registered for both IPv6
   and IPv4 home addresses. The mobile node cannot bind a 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 Binding Identifier mobility option.
   The status field of the IPv4 address Acknowledgement option contains
   only the error code defined in Section 4.2.1 of [ID-DSMIP6]. The
   home agent MUST always include the IPv4 address Acknowledgement
   mobility option in the Binding Acknowledgement for the IPv4 home
   address registration.

9. IPsec and IKEv2 interaction

   Mobile IPv6 [RFC-3775] and the NEMO protocol [RFC-3963] require the
   use of IPsec to protect signaling messages including Binding Updates,
   Binding Acknowledgement 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 Home Test Init
       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.

The home agent processes Mobile Prefix Discovery messages with the
same rules of data packets described in Section 6.5.

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 Home Test Init and Home Test
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 Home Test Init and Home Test messages

The mobile node MAY use the same care-of address for all Home Test
Init messages sent reverse tunneled through the home agent. The
mobile node may use the same care-of address irrespective of which
correspondent node the Home Test Init 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 Home Test Init 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 Home Test Init 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 Home Test message to the mobile node,
the care-of address used in the outer IPv6 header is not relevant to
the Home Test 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, the source address used in the
      outer IPv6 header is irrelevant to IPsec, since the tunnel mode
      security association is based on the addresses in the inner IPv6
      header. Therefore, the same IPsec security association can be
      used for payload traffic tunneled from any of the care-of
      addresses. Note that the care-of address used in the reverse
      tunneld traffic can be different from the care-of address used as
      the source address in the IKEv2 exchange. However, this does not
      cause an issue due to the above mentioned reason.

   o For tunneled IPsec traffic from the home agent to the mobile node,
      the IPsec implementation on the home agent will not be aware of
      which care-of address to use when performing IPsec tunnel
      encapsulation. The Mobile IP stack on the home agent, based on
      the binding cache entries created by the mobile node, knows which
      care-of address the packet belonging to a particular flow needs to
      be tunneled to. The destination address for the outer IP header
      must either by conveyed dynamically per packet to the IPsec stack
      when it performs the encapsulation or the Mobile IPv6 stack must
      get access to the packet after IPsec processing is done and modify
      the destination address. The first option requires changes to the
      IPsec implementation. In the second option, there is a need for
      special processing in the forwarding function to replace the
      destination address on the outer header with the correct care-of
      address. The exact technique to achieve the above is
      implementation specific.

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 are securely exchanged as described
in [RFC-3775], [RFC-4877] and 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 the 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 a risk exists in Mobile IPv6, the risk level is
increased 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.
These mechanisms are out-of scope for this document.

In the binding registration of Mobile IPv6, a care-of address is
always verified its reachability by a home agent. This reachability
test may decrease the above risks. However, when bulk registration
is used, a home agent cannot verify reachability of care-of addresses
carried in a Binding Identifier mobility option. Therefore, the home
agent can choose to reject bulk registration by using [MCOA BULK
REGISTRATION PROHIBITED] in a Binding Acknowledgement.
Alternatively, when a mobile node first registers a care-of address,
it uses the individual binding updates for the first appeared care-of
address. During the initial binding registration, a home agent can
verify the address reachability for that given care-of address.
After that, the mobile node uses bulk registration to refresh the
care-of address.

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 NON-MCOA BINDING EXISTS (TBD)

   * MCOA PROHIBITED(TBD)

   * MCOA UNKNOWN COA(TBD)

   * MCOA BULK REGISTRATION PROHIBITED (TBD)

   * MCOA SIMULTANEOUS HOME AND FOREIGN PROHIBITED (TBD)

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