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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, termed the primary care-of address, 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 access media simultaneously, in which case multiple active IPv6 care-of addresses would be assigned to the mobile node. We thus propose Mobile IPv6 extensions designed to register multiple care-of addresses bound to a single home address instead of the sole primary care-of address. For doing so, a new identification number must be carried in each binding for the receiver to distinguish between the bindings corresponding to the same home address. Those extensions are targeted to NEMO (Network Mobility) Basic Support as well as to Mobile IPv6.

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1. Introduction

Permanent Internet connectivity is required by some applications

while a mobile node moves across several access networks (i.e. ISPs, hotspots, etc). For example, it is desirable to maintain the Internet connectivity while an automobile running on a freeway receives voice or video streaming data from different access networks. Such motivations for multiple points of attachment, and benefits for doing it are discussed at large in [4]. The problem statement of multihomed mobile node is summarized in [7].

Unfortunately, there is no network interfaces assuring global scale connectivity. Therefore, a mobile node should use various type of network interfaces to obtain wide area network connectivity [9]. In addition, users should select the most appropriate network interface depending on a visiting network environment, since wireless networks are mutable and less reliable than wired networks and since each network interface has different cost, performance, bandwidth, access range, and reliability. Users should also be able to select the most appropriate interface per communication type. For example, TCP traffic should be transmitted over the wireless interface, whereas UDP traffic should be transmitted over the wired interface to avoid disturbing TCP connections.

Associating multiple care-of addresses to a single home address would allow durable Internet connectivity. For example, when a mobile node loses its Internet connectivity at one of its interface, the second interface can be used as a backup interface therefrom maintaining Internet connectivity. In addition, the mobile node can send each communication flow to a distinct network interface. This provides efficient network bandwidth consumption. A user can select the most suitable network interface per application. Correspondent nodes can also re-select a binding of the mobile node to recover communication when one of mobile node's bindings becomes invalid. To enable a binding selection policy, a mobile node can use the particular binding for specified communication type. If a mobile node does not have enough bandwidth for communications, it can utilize both bindings to gain network bandwidth. Furthermore, a mobile node may bicast packets of a particular flow through all available network interfaces.

IPv6 [1] conceptually allows a node to have several addresses on a given interface. Consequently, Mobile IPv6 [5] has mechanisms to manage multiple ``home addresses'' based on home agent's managed prefixes such as mobile prefix solicitation and mobile prefix advertisement. But assigning a single home address to a given network interface is more advantageous than assigning multiple home addresses because applications do not need to be aware of the multiplicity of home addresses. Of course, applications should be

aware of the active home address to be used for communicating. At the TCP layer, TCP holds the home address as a source address of the communication for connection management. Applications must be restarted to reset the connection information when the mobile node changes its active network interface (i.e. change the home address).

However, according to section 11.5.3 of the Mobile IPv6 specification [5], a mobile node is not allowed to register multiple care-of addresses bound to a single home address. If a mobile node sends Binding Updates for each care-of address, correspondent nodes would always overwrite the care-of address recorded in the binding cache with the one contained in the latest received binding update. It is thus impossible for a mobile node to register multiple care-of addresses in the correspondent node's binding cache.

In this document, we thus propose a new identification number called Binding Unique Identification number (BID) for each binding cache entry to accommodate multiple bindings registration. We also propose extension of binding cache management to store the BID and a new sub-option for binding update to carry the BID. The BID is assigned to either the interfaces or care-of addresses bound to a single home address of a mobile node. The mobile node notifies the BID to both its home agent and correspondent nodes by means of a Binding Update. Correspondent nodes and the home agent record the BID into their binding cache. The home address thus identifies a mobile node itself whereas the BID identifies each binding registered by a mobile node. By using the BID, multiple bindings can then be distinguished.

A user of a mobile node may be able to bind some policies to a BID. The policy is used to divide flows to multiple network interfaces by flow type, port number, or destination address, etc. How to distribute or configure policies is not within the scope of this document.

2. Terminology

Terms used in this draft are defined in [5] and [6]. We define or redefine the following ones:

Binding Unique Identification number (BID)

The BID is an identification number used to distinguish multiple bindings registered by the mobile node. Assignment of distinct BID allows a mobile node to register multiple binding cache entries for a given home address. The BID is generated to register multiple bindings in the binding cache for a given addess in a way it cannot be duplicated with another BID. The zero value and a negative value MUST NOT be used. After being generated by the mobile node, the BID is stored in the Binding Update List and is sent by the mobile node by means of a sub-option of a 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.

The BID can be assigned to either a care-of address or an interface depending on implementation choices 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.

Primary care-of address

In [5], the primary care-of address is defined as ``the care-of address registered with the mobile node's home agent is called its ``primary'' care-of address''. In this present document, the term is refined as ``the care-of address which is primarily associated with a home address''.

A mobile node MUST have a primary care-of address all the time. Once the primary care-of address becomes invalid, the mobile node MUST reselect a primary care-of-address from the set of other care-of addresses that it may also own at that time.

Primary Interface

The interface on which the primary care-of address is assigned. Once the primary interface becomes invalid, the mobile node MUST re-select a primary interface from the set of interfaces installed in the mobile node.

Binding Unique Identifier sub-option

The Binding Unique Identifier sub-option is used to carry the BID.

Multiple Care-of Addresses Flag (B flag)

This flag indicates that a Binding Unique Identifier sub-option is included in the Binding Update Mobility Option field.

3. Protocol Overview

We propose a new identification number to distinguish multiple bindings pertaining to the same home address. The procedures for the mobile node to register multiple bindings are described in the paragraphs below.

3.1. Multiple Care-of Addresses Registration

Once a mobile node gets several IPv6 global addresses on distinct interfaces, it MUST select a primary care-of address from the active addresses as specified in Section 11.5.3 [5]. After the selection, the interface which has the primary care-of address becomes the primary interface for the mobile node.

After selecting the primary care-of address, the mobile node MUST register it with its home agent (home registration). If the mobile node wants to register multiple bindings to its home agent, it MUST generate a BID for the primary care-of address and record it into the binding update list entry. The mobile node then registers its primary care-of address by sending a Binding Update with a Binding Unique Identifier sub-option. The B flag MUST be set in the Flag field of the Binding Update and the BID MUST be put in the Binding Unique Identifier sub-option. After receiving the Binding Update, the home agent verifies the request and records the binding in its binding cache. If the newly defined sub-option is present in the Binding Update, the home agent MUST copy the BID from the Binding Update to the corresponding field in the binding entry.

After this home registration, the mobile node SHOULD register the rest of care-of addresses to its Home Agent. Even if there is already an entry for the mobile node, the home agent MUST registers a new binding entry for the BID stored in the Binding Unique Identifier sub-option. The registration process is the same as for the

registration of the primary care-of address. The mobile node MUST register multiple care-of addresses independently.

If the mobile node wish to register its binding with a correspondent node, it MUST starts return routability operations before sending a Binding Update. The mobile node MUST sends CoTI for each care-of addresses and MUST receive CoT for each care-of addresses. The mobile node also generates a BID for each care-of addresses to register them as individual bindings. The registration step is the same as for the home registration except for calculating authenticator by using Binding Unique Identifier sub-option as well as the other sub-options specified in [5].

3.2. Multiple Bindings Management

The BID is used as a search key for a corresponding entry in the binding cache in addition to the home address. When the home agent checks the binding cache database for the mobile node, it searches a corresponding binding entry with the home address and BID of the desired binding. The desired binding can be selected with policy and filter information. The capability of searching the desired binding enables load-sharing and QoS with flow separation. But this selection and flow separation are out of scope in this draft. If there is no desired binding, it search the binding cache database with the home address as well as Mobile IPv6. The first matched binding entry may be found, but it searches the binding cache with the home address as it would for Mobile IPv6

If a node has multiple bindings and its packets meant for the mobile node are not delivered correctly, the node can change the binding entry for the mobile node so as to recover the connection immediately. The node can detect a binding invalidation by packets loss or ICMP error messages such as ICMP_UNREACHABLE. This provides redundancy for Mobile IPv6.

When one of the care-of addresses is changed, the mobile node sends a Binding Update with the new care-of address and the corresponding BID. The receiver of the Binding Update updates the binding which BID fits the BID contained in the received Binding Unique Identifier sub-option. The mobile node can manage each binding independently owing to BID.

If the mobile node decides to register only one binding, it just

sends a Binding Update without B flag and without a Binding Unique Identifier sub-option (i.e. normal Binding Update). The receiver of the Binding Update registers only a single binding for the mobile node. If the receiver has multiple bindings, one binding is registered without BID and the rest of bindings are deleted.

3.3. Returning Home

When the mobile node returns home, there are two situations, since the home agent defends the mobile node's home address by using proxy neighbor advertisement. It is impossible to utilize all the interfaces when one interface is attached to the home link and the others are attached to foreign link. If proxy Neighbor Advertisement for the home address is stopped, packets are always routed to the interface attached to the home link. If proxy is not stopped, packets are never routed to the interface attached to the home link.

The first situation is when the primary interface is attached to the home link. In this case, the mobile node MUST de-register all the bindings by sending a Binding Update which lifetime set to zero. The mobile node MAY NOT put any Binding Unique Identifier sub-options in this packet. Then, the receiver deletes all the bindings from its binding cache database. On the other hand, if the mobile node wants to delete binding entries respectively, it sends multiple de-registration Binding Updates for all BID (that is all registered care-of addresses). In those Binding Updates, the mobile node MUST store a Binding Unique Identifier sub-option. Only when the care-of address is the primary one and the destination is the home agent, the mobile node also set the 'P' flag in the Binding Unique Identifier sub-option to indicates stop proxying for the mobile node to the home agent. The 'P' flag is valid only when the destination of a Binding Update is a home agent.

The second situation is when a non-primary interface is attached to the home link. The primary care-of address takes precedence over the rest of addresses. The mobile node stops using the interface attached to the home link and keeps using the rest of interfaces attached to foreign links. In this case, the mobile node sends de-registration Binding Update with the Binding Unique Identifier sub-option. The mobile node stores the BID of the binding and MUST NOT set the 'P' flag in the sub-option regardless of home agent or not. Therefore, the receiver of the de-registration Binding Update

deletes only the binding entry from the binding cache database. The home agent does not stop proxying neighbor advertisement.

4. Mobile IPv6 Extensions

In this section are described the changes to allow Mobile IPv6 to manage multiple bindings bound to a same home address.

4.1. Binding Cache Structure and Management

Additional items are required in the binding cache structure, which are:

- BID of the binding cache entry. The BID is notified by the mobile node by means of a Binding Update sub-option. The value MUST be zero if the Binding Update does not contain a BID.

4.2. Binding Update Structure and Management

Additional items are required for the binding update structure, which are:

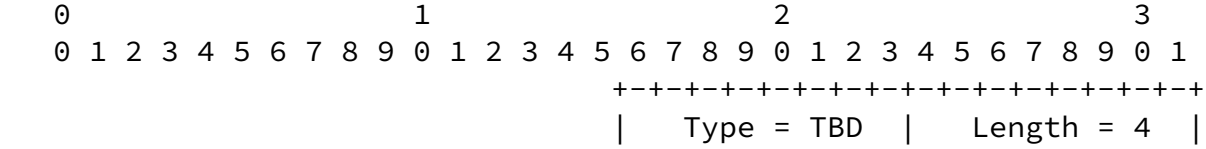
- BID: MUST be generated whenever the mobile node registers multiple bindings for its home address.

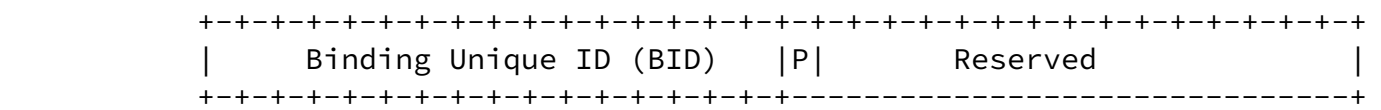
- Primary flag: MUST be set if the care-of address is primary.

4.3. Messages Format Changes

4.3.1. Binding Unique Identifier sub-option

The Binding Unique Identifier sub-option is included in Binding Update, Binding Acknowledgment, Binding Refresh Request, Binding Error if needed.





Type
Type value for Binding Unique Identifier will be assigned later.

Length
The value MUST be always 4.

Binding Unique ID (BID)
The BID which is assigned to the binding carried in the Binding Update with this sub-option. BID is 16-bit unsigned integer. A value of zero is reserved.

Flag

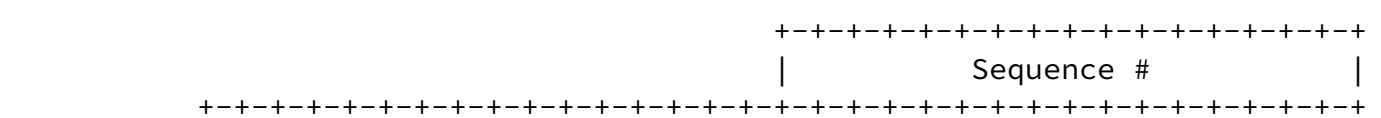
Stop Proxy Neighbor Advertisement (P) Flag

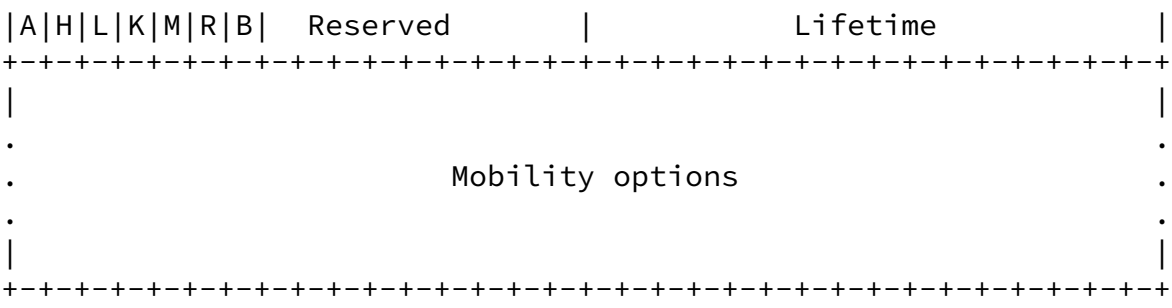
When this flag is set, the home agent MUST stop proxy neighbor advertisement for a mobile node. This flag is checked only when a Binding Update is for de-registration and the destination of a Binding Update is mobile node's home agent (i.e. home de-registration). Otherwise, this flag MUST be ignored

Reserved
15 bit Reserved field. Reserved field must be set with all 0.

4.3.2. Binding Update

The 'B' flag MUST be set and a Binding Unique Identifier sub-option MUST be included if the mobile node wants to bind multiple care-of address to a given home address.





Multiple Care-of Addresses Flag (B)
This flag is used for multiple care-of addresses registration.

Reserved
Reserved field is reduced to 9 bits.

4.3.3. Binding Acknowledgment

The message format of Binding Acknowledgment is not changed, but operations listed below are added in this draft.

A receiver who gets a Binding Update with the 'B' flag set MUST reply with a Binding Acknowledgment if the 'A' flag is also set or in case of a home registration. The receiver MUST also send a Binding Acknowledgment with corresponding error codes if it finds an error while processing the Binding Update and its sub-option described in section 4.3.2.

If a Binding Update has the 'B' flag set and a Binding Unique Identifier sub-option is present, the receiver node MUST reply with a Binding Acknowledgment containing the same Binding Unique Identifier sub-option. The mobile node can process the Binding Acknowledgment for the particular care-of address identified by the BID set in the Binding Unique Identifier sub-option.

A new number is defined for handling the 'B' flag:

- TBD (144)
  It implies conflicting a regular binding and a binding that has BID in binding cache. The regular binding indicates the binding that does not have BID field. The status value is TBD.

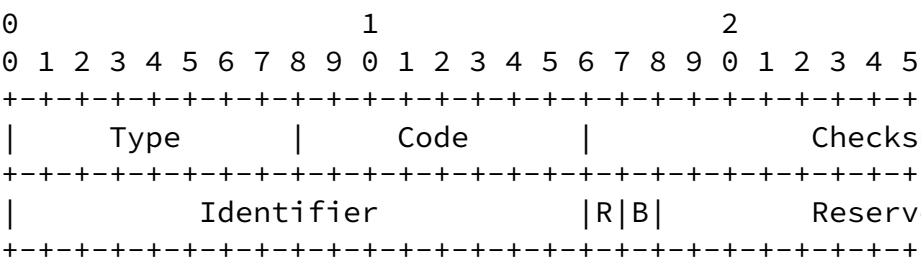
4.4. Dynamic Home Agent Address Discovery

The Dynamic Home Agent Address Discovery (DHAAD) defined in RFC3775 [5] is extended so that Mobile Nodes or Mobile Routers only register multiple care-of addresses with Home Agents that support multiple care-of addresses registration.

However, we do not provide a solution for Mobile Nodes that would like to register multiple care-of addresses only with Correspondant Nodes that support multiple care-of addresses registration.

4.4.1. DHAAD Request

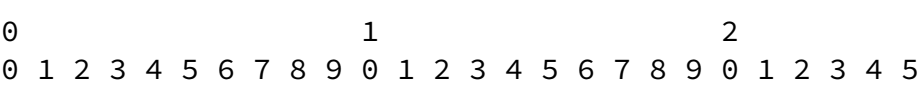
A new 'B' flag is introduced in the DHAAD Request message in order to discover Home Agents supporting the multiple care-of address registration.

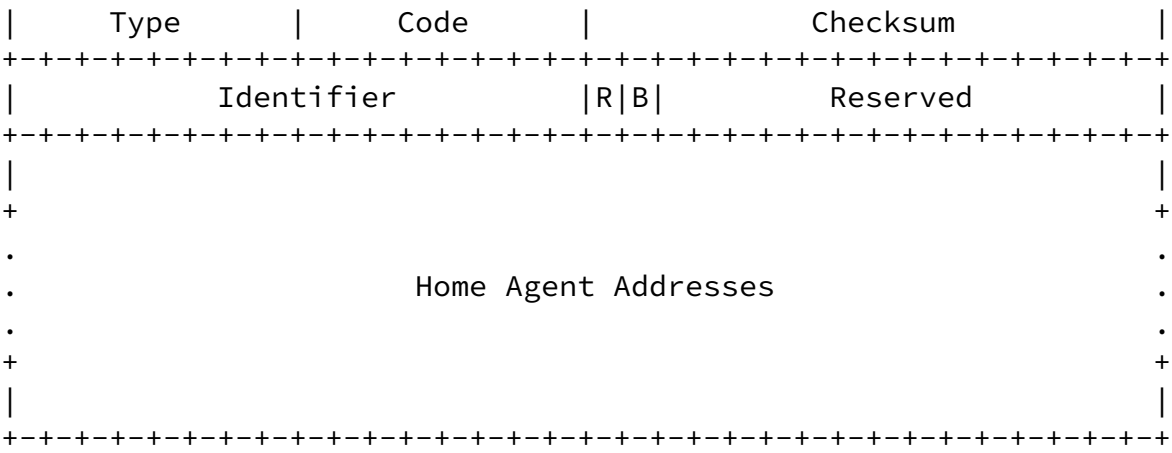


Multiple Care-of Addresses Flag (B)
This flag is set when the mobile node wants to discover Home Agents that support multiple care-of addresses registration.

4.4.2. DHAAD Reply

A new 'B' flag is introduced in the DHAAD Reply message. When a Home Agent receives a DHAAD Request message with the Multiple Care-of Addresses support Flag set, it MUST reply with a list of Home Agents supporting the multiple care-of addresses registration. The 'B' flag MUST be set in the DHAAD Reply.



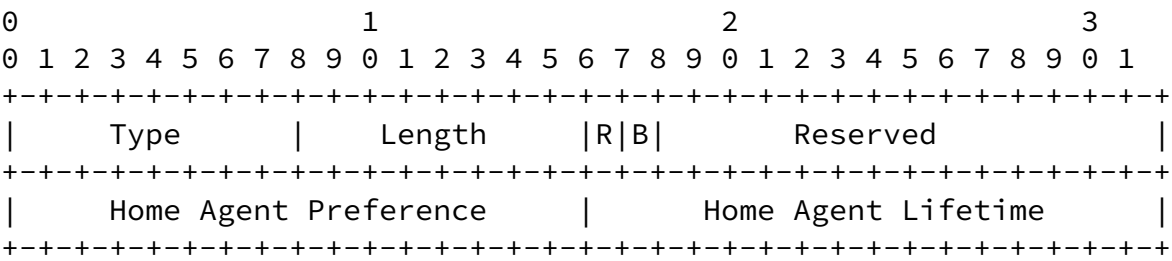


Mobile Router Flag (R)
This flag is proposed by the NEMO working group [2].

Multiple Care-of Addresses Flag (B)
This flag is set when the Home Agents listed in this message support the multiple care-of addresses registration.

4.4.3. Home Agent Information Option

A new 'B' flag is introduced in the Home Agent Information Option. The home agent SHOULD set the flag if it supports multiple care-of addresses registration.



Mobile Router Flag (R)
This flag is proposed by the NEMO working group [2].

Multiple Care-of Addresses Flag (B)
This flag is set when the Home Agent supports multiple care-of addresses registration.

5. Mobile Node Operation

5.1. Management of care-of addresses and Binding Unique Identifier

There are two cases when a mobile node has several care-of addresses:

- A mobile node uses several physical network interfaces and acquires a care-of address on each of its interfaces.

- A mobile node uses a single physical network interface, but multiple prefixes are announced on the link the interface is attached to. Several global addresses are configured on this interface for each of the announced prefixes.

The difference between the above two cases is only a number of physical network interfaces and therefore does not matter. The Identification number is used to distinguish multiple bindings so that the mobile node assigns an identification number for each care-of addresses. How to assign an identification number is up to implementors.

A mobile node assigns a BID to each care-of address when it wants to simultaneously register with its home address. The value should be generated from a value comprised between 1 to 65535. Zero and negative value can not be taken as a BID. 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.

5.2. Sending Binding Update

When a mobile node sends a Binding Update to its home agent (i.e. home registration) and the Binding Update is aimed to de-register the binding, the mobile node MUST check whether the care-of address contained in the Binding Update is primary or not. If the care-of address is a primary one, it MUST set the 'P' flag in the Binding Unique Identifier sub-option. More description about the 'P' flag can be found in Section 5.3.

When a mobile node sends a Binding Update, it MUST decide whether it registers multiple care-of addresses or not. However, this decision is out-of scope in this document. If a mobile node decides not to register multiple care-of addresses, it completely follows standard Mobile IPv6 [5].

On the other hand, if the mobile node needs to register multiple care-of addresses, it MUST use BIDs all the time. The mobile node sets B flag in a Binding Update and puts a Binding Unique Identifier sub-option into the Option field of the Binding Update. The BID is

copied from a Binding Update List to the Binding Unique Identifier sub-option. If the mobile node registers bindings to a correspondent node, it MUST sends multiple CoTI for multiple care-of addresses. After getting CoTs, it sends Binding Updates with the 'B' flag set and a Binding Unique Identifier sub-option for all care-of addresses, one by one. In any case, the mobile node MUST set the 'A' flag in Binding Updates and MUST wait for a Binding Acknowledgment to confirm the registration was successful as described in section 5.5.

Note that there is no optimization such as registering multiple care-of addresses by using a single Binding Update, because the current Mobile IPv6 specification does not allow to send multiple bindings by means of a single Binding Update.

5.3. De-registration

When a mobile node decides to delete all bindings for its home address, it sends a regular de-registration Binding Update (i.e. unset of 'B' flag and exclusion of a Binding Unique Identifier sub-option). See Section 6.2 for details.

If a mobile node wants to delete a particular binding from its home agent and correspondent nodes, it follows the operations below.

When a mobile node is attached to its home link by one of its network interfaces, it MUST de-register an appropriate binding. If a binding of a primary care-of address becomes invalid after the mobile node returns home, it MUST set the 'P' flag in a Binding Unique Identifier sub-option. Otherwise, the 'P' flag MUST NOT be set. If the 'P' flag is set, the home agent stop proxy neighbor advertisement for the mobile node. The 'P' flag is ignored if the receiver is not the home agent.

When the mobile node's primary interface gets attached to the home link (see Figure 3 and Figure 5 in Appendix B), the Mobile Node MUST start de-registration processing to its home agent as indicated in Mobile IPv6. The home agent deletes all bindings for the mobile node and stops intercepting packets meant for the mobile node. Although the mobile node MUST deletes the binding at correspondent nodes as well, the node can still keep the binding of the non-primary interface active at the correspondent nodes. In such case, the mobile node still receives packets at a non-primary interface attached to a foreign link thanks to route optimization. The mobile node also receives packets at the primary interface attached to the home link when correspondent nodes does not use route optimization.

On the other hand, when the mobile node's non-primary interface gets attached back to the home link (see Figure 4 in Appendix B),

the mobile node MUST delete only the particular binding from its home agent and correspondent nodes. The home agent does not delete all bindings and does not stop proxy neighbor advertisement for the mobile node. Therefore, the mobile node no longer receives packets at the non-primary interface attached to the home link. All packets are routed to other interfaces attached to a foreign link. If the mobile node is eager to receive packets at the non-primary interface at the home link, it MUST re-select the interface as the primary one.

5.4. Using Alternate Care-of Address

A mobile node can use an alternate care-of address in the following situations.

- One care-of address becomes invalid (e.g because the link where it is attached is no longer available) and MUST be deleted. In such case, the mobile node can not sends a Binding Update from the care-of address because the interface's link is lost. The mobile node needs to de-register the remote binding of the care-of address through one of its active care-of addresses.

- A mobile node has multiple interfaces, but it wants to sends Binding Updates for all care-of addresses from a specific interface which has wider bandwidth depending on interface's characteristics. A mobile node does not want to send a lot of control messages through an interface which bandwidth is scarce.

In these cases, the mobile node sends a Binding Update with both Alternate Care-of Address sub-option and Binding Unique Identifier sub-option. The processing of Alternate Care-of Address sub-option is described in the Mobile IPv6 specification. If there is an Alternate Care-of Address sub-option, the BID in a Binding Unique Identifier sub-option is assigned for the care-of address in the Alternate Care-of Address sub-option.

5.5. Receiving Binding Acknowledgment

The verification of a Binding Acknowledgment is the same as in Mobile IPv6 (section 11.7.3 of [5]). The operation for sending a Binding Acknowledgment is described in 6.3.

If a mobile node sends a Binding Update with a Binding Unique Identifier sub-option, a Binding Acknowledgment MUST have a Binding Unique Identifier sub-option in the Mobility options field. If there is no such sub-option, the originator node of this Binding Acknowledgment might not recognize the Binding Unique Identifier sub-option. The mobile node SHOULD stop registering multiple care-of

addresses by using a Binding Unique Identifier sub-option. If the originator is the Home Agent, the mobile node MAY perform DHAAD to discover a new Home Agent supporting the multiple care-of address registration.

If a Binding Unique Identifier sub-option is present, the mobile node checks the Status field of the Binding Acknowledgment. If the status code indicates successful registration (below 128), the originator registers a binding information and BID for the mobile node successfully.

If the status code is not zero regardless of Binding Unique Identifier sub-option availability in BA, the mobile node proceeds an relevant operations according to the status code.

If the status code is 144, the mobile node has already registered a regular binding before sending a Binding Update with a Binding Unique Identifier sub-option. In such case, the mobile node SHOULD stop sending Binding Updates without BID.

5.6. Receiving Binding Refresh Request

The verification of a Binding Refresh Request is the same as in Mobile IPv6 (section 11.7.4 of [5]). 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 Unique Identifier sub-option, this Binding Refresh Request requests a binding indicated by the BID. The mobile node SHOULD update only the respective binding. The mobile node MUST put a Binding Unique Identifier sub-option into a Binding Update.

If no Binding Unique Identifier sub-option is present in a Binding Refresh Request, the mobile node sends a Binding Update according to its Binding Update List for the requesting node. On the other hand, if the mobile node does not have any Binding Update List entry for the requesting node, the mobile node needs to register either a single binding or multiple bindings depending on its binding management policy.

5.7. Receiving Binding Error

When a mobile node receives a Binding Error with a Binding Unique Identifier sub-option, the message is for a binding indicated by the BID in the Binding Unique Identifier sub-option. Further operations except for the text below are identical as in [5]. The operation for sending BE is described in the section 6.5.

When a mobile node receives a Binding Error with Status field set to 2 (unrecognized MH Type value) , it MAY stop trying to register multiple care-of addresses and registers only primary care-of address as performed in Mobile IPv6.

6. Home Agent and Correspondent Node Operation

6.1. Searching Binding Cache with Binding Unique Identification Number

If a correspondent node has multiple bindings for a mobile node in its binding cache database, it can use any of the bindings to communicate with the mobile node. How to select the most suitable binding from the binding cache database is out of scope in this document.

Whenever a correspondent node searches a binding cache for a home address, it SHOULD uses both the home address and the BID as the search key if it knows the corresponding BID. Below is an example of multiple bindings for a home address in the binding cache database. If a correspondent node searches the binding with the home address and BID2, it gets binding2 for this mobile node.

binding1 [a:b:c:d::EUI care-of address1 BID1]

```
binding2 [a:b:c:d::EUI  care-of address2  BID2]
binding3 [a:b:c:d::EUI  care-of address3  BID3]
```

A correspondent node basically learns the BID when it receives a Binding Unique Identifier sub-option. At the time, the correspondent node MUST look up its binding cache database with the home address and the BID retrieved from Binding Update. If the correspondent node does not know the BID, it searches a binding with only a home address as performed in Mobile IPv6. In such case, the first matched binding is found. But which binding entry is returned for the normal search depends on implementations. If the correspondent node does not desire to use multiple bindings for a mobile node, it can simply ignore the BID.

6.2. Receiving Binding Update

If a Binding Update has neither 'B' flag set nor a Binding Unique Identifier, the processing of the regular Binding Update is the same as in [5]. But if the receiver already has multiple bindings for the home address, it MUST overwrite all existing bindings for the mobile node with the received binding. As a result, the receiver node MUST have only a binding for the mobile node. If the Binding Update is

for de-registration, the receiver MUST delete all existing bindings for the mobile node.

On the other hand, if a Binding Update contains a Binding Unique Identifier sub-option or the 'B' flag is set, a receiver node MUST operate additional validations as follows:

- A receiver node MUST validate the Binding Update according to section 9.5.1 of [5].
- If the Binding Update has the 'B' flag set at the Flag field, a Binding Unique Identifier sub-option MUST be present in Mobility options field of the Binding Update.
- If there is no Binding Unique Identifier sub-option with the 'B' flag set, the receiver node MUST silently drop the Binding Update.
- If the Binding Unique Identifier sub-option is present, the

receiver node MUST process the Binding Update.

- If the Lifetime field is not zero, the receiver node registers a binding that includes the BID as a mobile node's binding.

  * If the receiver does not have any binding for the mobile node, it registers a binding which includes BID field.

  * If the receiver has a regular binding which does not have BID for the mobile node, it de-registers the regular binding and registers a new binding including BID according to the Binding Update. In this case, the receiver MUST send Binding Acknowledgment with status code set to 144.

  * If the receiver node has already registered the binding which BID is matched with requesting BID , then it MUST update the binding up-to-date with the Binding Update. Meanwhile, if the receiver does not have a binding entry which BID is matched with the requesting BID, it registers a new binding for the BID.

- If Lifetime field is zero, the receiver node deletes the registering binding entry which BID is same as BID sent by the Binding Unique Identifier sub-option. If the receiver node does not have appropriate binding which BID is matched with the Binding Update, it MUST reject this de-registration Binding Update. If the receiver is a Home Agent, it SHOULD also return a Binding Acknowledgement to the mobile node, in which the Status field is set to 133 (not home agent for this mobile node).

Note if the mobile node sends multiple Binding Updates with a different BID but for same care-of address (i.e. same home address, same care-of address, and different BID) , the receiver SHOULD register both bindings into its binding cache.

6.3. Sending Binding Acknowledgment

If a Binding Update does not contain a Binding Unique Identifier sub-option, the receiver, either a correspondent node or a home agent, MUST reply with a Binding Acknowledgment according to section 9.5.4 of [5]. Otherwise, whenever the BID sub-option is present, the receiver MUST follow the additional procedure below. The receiver

MUST reply with a Binding Acknowledgment whether the 'A' flag is set or not in the Binding Update.

If the receiver successfully registers a binding for the BID stored in a Binding Unique Identifier sub-option, it returns a Binding Acknowledgment with Status field set to successful value (0 to 128) and a Binding Unique Identifier sub-option copied from the received Binding Update. If the receiver deletes the existing binding which does not have a BID and registers a new binding for the BID, it MUST return a Binding Acknowledgment with Status field set to '144'. On the other hand, if the node encounters an error during the processing of a Binding Update, it must return a Binding Acknowledgment with an appropriate error number as described in [5]. The node SHOULD put a Binding Unique Identifier sub-option if the BID is available for the Binding Acknowledgment.

6.4. Sending Binding Refresh Request

When either a correspondent node or Home Agent notices that a registered binding will be expired soon, it SHOULD send a Binding Refresh Request. If the registered binding has BID, the correspondent node SHOULD contain a Binding Unique Identifier sub-option in the Binding Refresh Request. Then, the correspondent node can receive a Binding Update with a Binding Unique Identifier sub-option and can update only the particular binding. If the registered binding does not have BID, then the correspondent node sends a Binding Refresh Request without the sub-option.

6.5. Sending Binding Error

When a correspondent node sends a Binding Error with Status field set to 2 (Unrecognized MH Type value), it MAY put a Binding Unique Identifier sub-option into Mobility Options field if BID is available in a received binding message.

When a correspondent node receives data packets with a home address destination option, it verifies the IPv6 source address field. If the source address is not registered in the correspondent node's binding cache, the correspondent node MUST return a Binding Error to the sender with the status set to zero (Unknown binding for Home Address destination option). The correspondent node can not put a

Binding Unique Identifier sub-option, because there is no binding cache entry for the source address.

7. Network Mobility Applicability

Support of multihomed mobile routers is advocated in the NEMO working group (see R12 ``The solution MUST function for multihomed MR and multihomed mobile networks'' in [3]).

Issues regarding mobile routers with multiple interfaces and other multihoming configurations are documented in [8].

Since the binding management mechanisms are the same for a mobile host operating Mobile IPv6 and for a mobile router operating NEMO Basic Support [2], our extensions can also be used to deal with multiple care-of addresses registration sent from a multihomed mobile router.

A mobile router MUST NOT use the 'P' flag when its home agent does not use proxy neighbor advertisement to intercept packets destined to the mobile router. This situation occurrs when the home link is configured as a virtual home link as detailed in extended home address described in [10].

A. A Scenario: Access both Carrier Packet Network and the Internet

This scheme can be applied to many scenarios such as described in [4]. Additionally, there is a specific scenario where this scheme is specially required.

A carrier often provides an independent networks from the Internet. For example, a Japanese carrier, NTT, provides a Flet's network for ADSL and FTTH users. The Flet's network is isolated from the Internet and is independent from the ISP, but can be accessed only from the NTT's ADSL and the FTTH physical lines.

Similar services are well expected to mobile wireless services. When a mobile node has a W-CDMA and a 802.11b interfaces with the network topology described in Figure 1, application servers limit connection only from the W-CDMA celluler network.

In such case, even if a mobile node is armed with Mobile IPv6, the

application servers will reject the connection from 802.11b. If the mobile node intelligently selects the W-CDMA for the application servers, the mobile node can use 802.11b for other traffic. The mobile node simply uses this scheme.

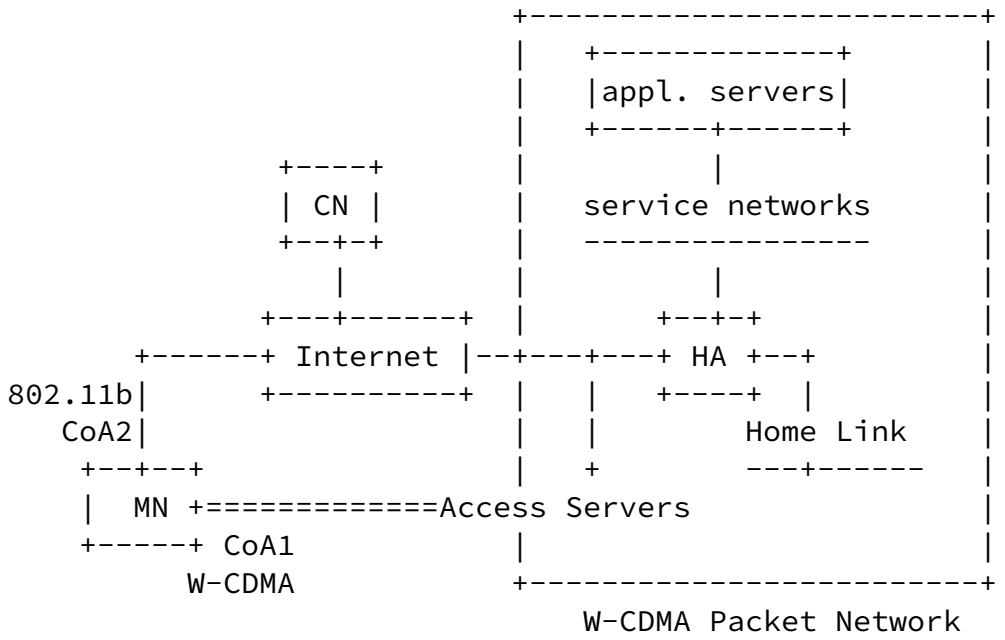


Figure 1: Service operated by a combination of a Packet Network and the Internet.

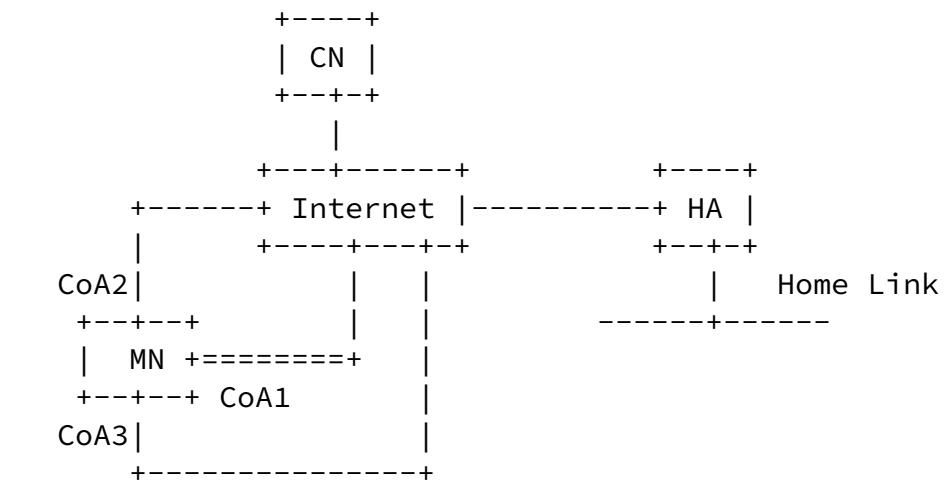
B. Example Configurations

In this section, we describe typical scenarios when a mobile node has multiple network interfaces and acquires multiple care-of addresses bound to a home address.

The home address of the mobile node (MN in figures) is a:b:c:d::EUI. MN has 3 different interfaces and possibly acquires care-of addresses 1-3 (CoA1, CoA2, CoA3). The MN assigns BID1, BID2 and BID3 to each care-of addresses.

Figure 2 depicts the scenario where all interfaces of the mobile node are attached to foreign links. After binding registrations, the home agent (HA) and the correspondent node (CN) have the binding entries listed in Figure 2 in their binding cache database. The mobile node

can utilize all the interfaces.

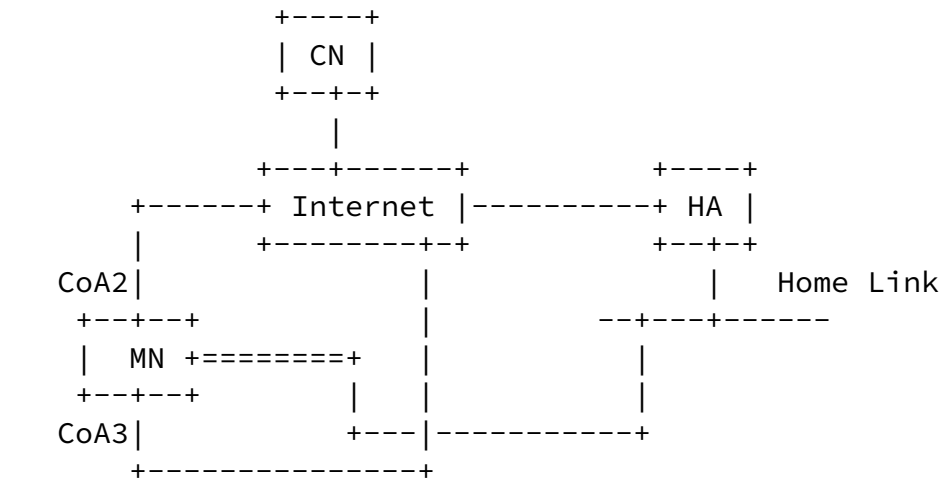


Binding Cache Database:
Home Agent's binding (Proxy neighbor advertisement is active)
binding [a:b:c:d::EUI care-of address1 BID1]
binding [a:b:c:d::EUI care-of address2 BID2]
binding [a:b:c:d::EUI care-of address3 BID3]
Correspondent Node's binding
binding [a:b:c:d::EUI care-of address1 BID1]
binding [a:b:c:d::EUI care-of address2 BID2]
binding [a:b:c:d::EUI care-of address3 BID3]

Figure 2: Multiple Interfaces are attached to Foreign Link

Figure 3 depicts the scenario where the primary interface of MN is attached to the home link.

After the successful registration of the binding, HA and CN have the binding entries listed in Figure 3 in their binding cache database. MN can communicate with the HA through only the primary interface attached to the home link. On the other hand, the mobile node can communicate with CN by using route optimization. Even when MN is attached to the home link, it can still send Binding Updates for other active care-of addresses (CoA2 and CoA3). If CN has bindings, packets are routed to each care-of addresses directly. Any packet arrived at HA are routed to the primary interface.



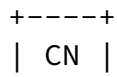

```
Binding Cache Database:
   Home Agent's binding (Proxy neighbor advertisement is inactive)
         none
   Correspondent Node's binding
         binding [a:b:c:d::EUI  care-of address2  BID2]
         binding [a:b:c:d::EUI  care-of address3  BID3]
```

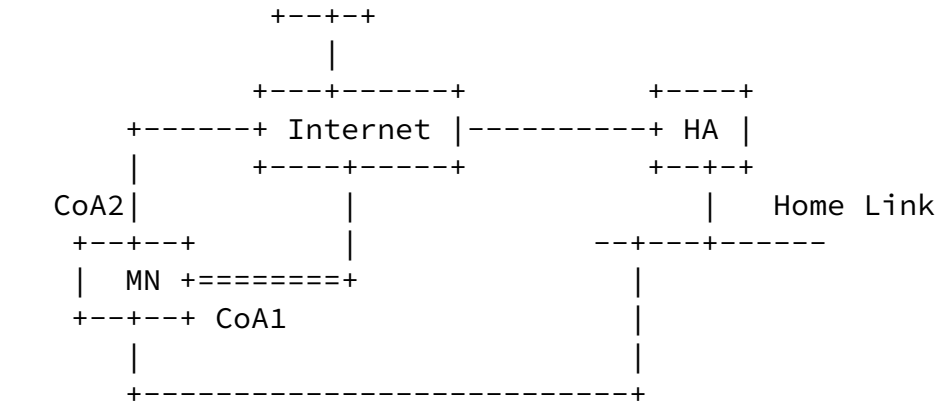
Figure 3: Primary Interface is attached to Home Link

Figure 4 depicts the scenario where a non-primary interface of a MN is attached to the home link.

The HA and the CN have the binding entries listed in Figure 4 in their binding cache database. MN can not utilize the non-primary interface attached to the home link, because the HA still defends the home address of the MN by proxy neighbor advertisements. All packets routed to the home link are intercepted by the HA and tunneled to the other interfaces attached to the foreign link according to the binding entries.

Figure 5 depicts the scenario where primary and a non-primary interface of MN are attached to the home link. The HA and the CN

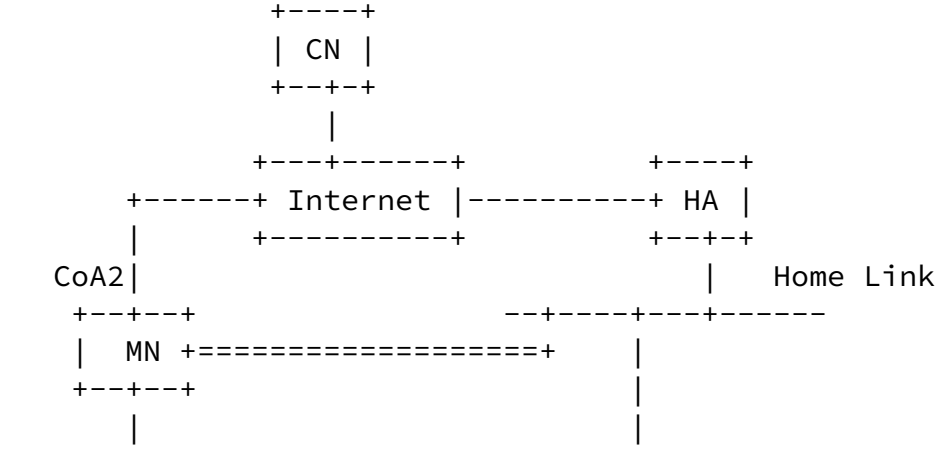





```
Binding Cache Database:
   Home Agent's binding (Proxy neighbor advertisement is active)
         binding [a:b:c:d::EUI  care-of address1  BID1]
         binding [a:b:c:d::EUI  care-of address2  BID2]
   Correspondent Node's binding
         binding [a:b:c:d::EUI  care-of address1  BID1]
         binding [a:b:c:d::EUI  care-of address2  BID2]
```

Figure 4: One of Non-Primary Interfaces is attached to Home Link

have the binding entries listed in Figure 5 in their binding cache database. The MN can not use the non-primary interface attached to a foreign link unless a CN has a binding for the non-primary interface. All packets which arrive at the HA are routed to one of interfaces attached to the MN. The HA decides an interface anyway, for example, by using policy and filters.



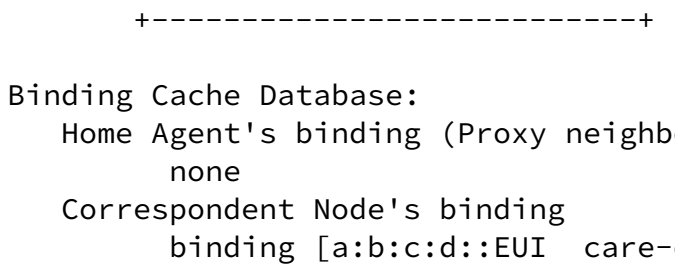


Figure 5: Primary and Non-Primary Interfaces are attached to Home Link

C. Changes

- Updating packet formats. M flag is re-named to B flag as suggested by [11].

- Adding extended operations for DHAAD packets in terms of finding Home Agent supporting multiple CoAs registration.

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