Monami6 Working Group
Internet-Draft
Expires: December 14, 2006

R. Wakikawa
Keio University
T. Ernst
Keio University / WIDE
K. Nagami
INTEC NetCore
June 12, 2006

Multiple Care-of Addresses Registration
draft-ietf-monami6-multiplecoa-00.txt

Status of this Memo

Copyright Notice

Abstract

According to the current Mobile IPv6 specification, a mobile node may have several Care-of Addresses, but only one, 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.

Table of Contents

1. Introduction

Permanent Internet connectivity is required by some applications while a mobile node moves across several access networks (i.e. ISPs, hotspots, etc). Unfortunately, there is no network interfaces assuring global scale connectivity. Therefore, a mobile node should use various type of network interfaces to obtain durable and wide area network connectivity [8]. 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 scenarios and motivations for multiple points of attachment, and benefits for doing it are discussed at large in [9].

Once multiple interfaces are available to a mobile node, a backup interface can be used to recover from the loss of Internet connectivity on the other interface, therefrom maintaining Internet connectivity of wide spread and reach. In addition, each communication flow could be sent to a distinct network interface, providing efficient network bandwidth consumption. It becomes possible for users to 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.

IPv6 [1] conceptually allows a node to have several addresses on a given interface. Consequently, Mobile IPv6 [2] 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, 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. Moreover, since NEMO Basic Support [3] is based on Mobile IPv6, the same issues applies to a mobile node acting as mobile router.

Multihoming issues pertaining to mobile nodes operating Mobile IPv6 and mobile routers operating NEMO Basic Support are respectively discussed [4] and [10] in Monami6 and NEMO Working Group.

In this document, we thus propose a new identification number called Binding Unique Identification (BID) number 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 [2], [5] and [6]. In addition or in replacement of these, the following terms are defined or redefined:

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 address 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.

Binding Unique Identifier sub-option

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

Bulk Registration

A mobile node can register multiple bindings by sending a binding update. Several care-of addresses can be stored in a Binding Update. The bulk registration is supported only for home registration. Note that a mobile node should not try to perform bulk registration with Correspondent Nodes.

3. Protocol Overview

We propose a new identification number (BID) 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 interfaces, it can register these addresses 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 each Care-of Address and record it into the binding update list. The mobile node then registers its Care-of Addresses by sending a Binding Update with a Binding Unique Identifier sub-option. 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. Even if there is already an entry for the mobile node, the Home Agent MUST register a new binding entry for the BID stored in the Binding Unique Identifier sub-option. The mobile node registers multiple Care-of Addresses either independently (in individual BUs) or multiple at once (in a single BU).

If the mobile node wishes to register its binding with a Correspondent Node, it MUST start 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 uses a BID generated for the home registration 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 RFC 3775. Since return routability cannot be verified with multiple care-of addresses in a binding update, bulk registration is not supported with Correspondent Nodes in this document.

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. If a mobile node registers a binding with priority value, the priority can be a key to select a binding. The capability of searching the desired binding enables load-sharing and QoS with flow separation. However, this selection and flow separation are outside the scope of this document.

If there is no desired binding, it searches the binding cache database with the Home Address as specified in Mobile IPv6. The first matched binding entry may be found, although this is implementation dependent.

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 single binding, it just sends a Binding Update 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 the 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 links. If the 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 decision whether a mobile node returns home or not is up to implementors.

The first situation is when a mobile node wants to return home with interface attached to the home link. In this case, the mobile node

MUST de-register all the bindings by sending a Binding Update with lifetime set to zero. The mobile node MAY NOT put any Binding Unique Identifier sub-option in this packet. Then, the receiver deletes all the bindings from its binding cache database.

The second situation is when a mobile node does not want to return home, though one of its interfaces is attached to its home link. The mobile node disables 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 a de-registration Binding Update for the interface attached to the home link with the Binding Unique Identifier sub-option. The receiver of the de-registration Binding Update deletes only the correspondent binding entry from the binding cache database. The Home Agent does not stop proxying neighbor advertisement unless there are still bindings for the other interfaces.

In the above two cases, a mobile node cannot use interfaces attached to both home and foreign links simultaneously. If this is what a mobile node wants, a home agent can set up another link other than home link and uses the link for the mobile node to return virtually to home network. The detail can be found in Figure 7

4. Mobile IPv6 Extensions

In this section are described the changes to Mobile IPv6 necessary to manage multiple bindings bound to a same Home Address.

4.1. Binding Cache Structure and Management

The following additional items are required in the binding cache structure, i.e.:

BID of the Binding Cache Entry

The BID is notified by the mobile node by means of a Binding Unique Identifier sub-option. The value MUST be zero if the Binding Unique identifier does not appear in a Binding Update.

Priority of the Binding Cache Entry

The priority is notified by the mobile node by means of a Binding Unique Identifier sub-option.

4.2. Binding Update List Structure and Management

The following additional items are required for the binding update structure, i.e.:

BID

The BID MUST be generated whenever the mobile node registers multiple bindings for its Home Address.

Priority

MUST be set if the priority field of a Binding Unique Identifier is valid.

4.3. Message Format Changes

4.3.1. Binding Unique Identifier sub-option

If needed, the Binding Unique Identifier sub-option is included in the Binding Update, Binding Acknowledgment, Binding Refresh Request, or Binding Error messages.

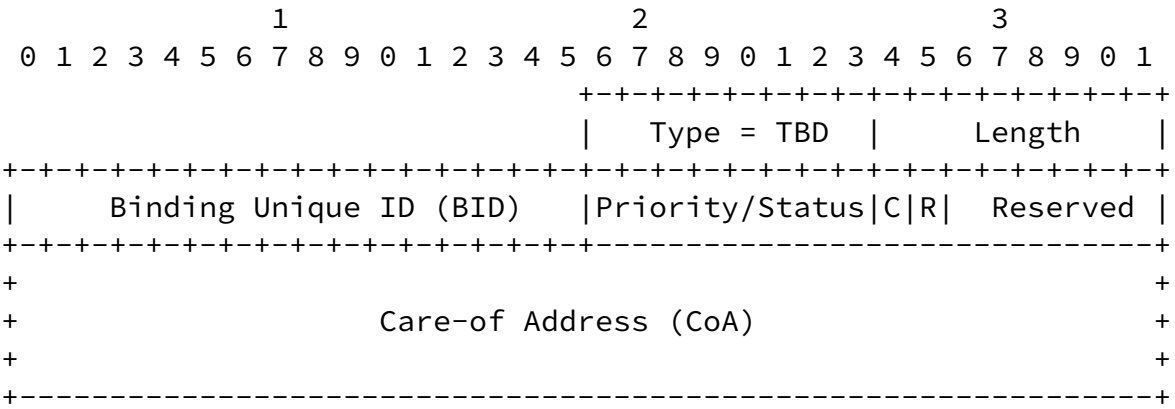


Figure 1: BID Sub-Option

Type

Type value for Binding Unique Identifier will be assigned later.

Length

Length value is 4 when the C flag is unset. Length value is 20 when the C flag is set.

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.

Priority/Status

When the Binding Unique Identifier sub-option is included in a Binding Update, this field indicates the priority field assigned to each binding. The receiver can utilize this priority to determine which binding is used to deliver packets. The priority is 8-bit unsigned integer. A value of zero indicates No Priority. The higher value has higher priority.

When the Binding Unique Identifier sub-option is included in a Binding Acknowledgment, this field indicates the status correspondent to each binding in a bulk registration mode. The mobile node can know the registration status of each binding. The status is 8-bit unsigned integer. The possible status codes are listed below. If the status field is below 128, it indicates that the binding registration was successful.

ACCEPTING BID SUBOPTION (0)

The registration of the correspond binding is successfully operated.

INCOMPLIANT BID SUBOPTION (128)

Registration failed because Binding Unique Identifier sub-option is not compliant.

Care-of Address (C) flag

When this flag is set, a mobile node can store a Care-of Address correspondent to BID in the Binding Unique Identifier sub-option. This flag must be used whenever a mobile node sends multiple bindings in a single Binding Update, i.e. bulk registration.

Removable (R) flag: TBD

When this flag is set, a mobile node request a Home Agent to remove the binding correspondent to BID, even if the binding update is not for de-registration. This flag is valid only when bulk registration is used (C flag is set). This option may be obsolete in the future revision.

Reserved

6 bits Reserved field. Reserved field must be set with all 0.

4.3.2. Binding Update

No modification to Binding Update. A mobile node stores a Binding Unique Identifier option in the Mobility Options field of a Binding Update.

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 a Binding Unique Identifier option MUST reply with a Binding Acknowledgment if the A flag is also set. 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 Section 4.3.

If a Binding Update has 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(s). There are two status fields of multiple care-of address registration: one in Binding Acknowledgment and another in Binding Unique Identifier sub-option. The first field indicates the general registration status and the latter field gives detail registration information for each binding. The latter field is often used to indicate status information for multiple bindings stored in a single binding update (i.e. bulk registration). New status values for the status field in Binding Acknowledgment are defined for handling the multiple Care-of

Addresses registration:

MCOA CONFLICT(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.

BULK REGISTRATION FAIL (145)

It implies that the bulk binding registration is failed. The correspondent status which is defined in RFC3775 is stored in each Binding Unique Identifier sub-option. The status value is TBD.

BULK REGISTRATION NOT SUPPORT (146)

It implies that the bulk binding registration is not supported.

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.

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:

1. A mobile node uses 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 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. Binding Registration

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 RFC 3775 specification.

If the mobile node needs to register multiple Care-of Addresses, it MUST use BIDs to identify a Care-of Address. The mobile node 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. No flag in the Binding Unique Identifier sub-option should be set for independent binding registration.

If the mobile node registers bindings to a Correspondent Node, it MUST sends multiple CoTIs for multiple Care-of Addresses. After getting CoTs, it sends Binding Updates with a Binding Unique Identifier sub-option for all Care-of Addresses. 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 Section 5.7.

5.3. Binding Bulk Registration

This bulk registration is an optimization for registering multiple Care-of Addresses only to a Home Agent by using a single Binding Update, although the current Mobile IPv6 specification does not allow to send multiple bindings by means of a single Binding Update. In this case, a mobile node sets the C flag into a Binding Unique Identifier sub-option and stores the particular Care-of Address in the Binding Unique Identifier sub-option. The mobile node can store multiple sets of a Unique Binding Identifier sub-option in a Binding Update. All the other binding information such as Lifetime, Sequence Number, binding Flags are shared among the bulk Care-of Addresses. Whether a mobile node registers multiple Care-of Addresses separately or not is up to implementations.

If one of Care-of Address should be removed while the other Care-of Address must be updated, a mobile node can set the R flag in a Binding Unique Identifier sub-option correspondent to the removed Care-of Address. When the R flag is set, the binding will be removed from the binding cache of the Home Agent. Other bindings for which R flag is unset will be registered or updated accordingly.

5.4. Binding 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. 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 (e.g. from foreign link), it MUST send a Binding Update with lifetime is set to zero. If only single Care-of Address is removed by a Binding Update, the mobile node simply sets zero lifetime in a Binding Update and contains the single correspondent Unique Binding Identifier Sub-option (C flag must be unset). The receiver will remove only the Care-of Address which is retrieved from the Source Address field of the IPv6 header. On the other hand, if the mobile node wants to remove multiple Care-of Addresses at once, it stores multiple Unique Binding Identifier sub-options which C flag is set in a Binding Update. The Care-of Addresses stored in the Binding Unique Identifier sub-options will all be removed.

If a mobile node wants to remove a binding while it registers the

other valid bindings, it can use R flag in a Binding Unique Identifier sub-option. The detailed operation can be found in Section 5.3.

5.5. Returning Home

When a mobile node returns home, it MUST de-register all bindings with the Home Agent.

Although the mobile node MUST delete the bindings with Correspondent Nodes as well, the node can still keep the binding of the other interface active attached to foreign links at the Correspondent Nodes. In such case, the mobile node still receives packets at the other interface attached to a foreign link thanks to route optimization. The mobile node also receives packets at the interface attached to the home link when Correspondent Nodes does not use route optimization.

Note that when the mobile node does not want to return home even if one of interfaces is attached to the home link, the mobile node MUST disable the interface. Otherwise, address duplication will be observed because the Home Agent still defend the Home Address by the proxy neighbor advertisement and the mobile node also enables the same Home Address on the home link. After disabling the interface attached to the home link, the mobile node MUST delete the binding for the interface by sending a de-registration binding update. The de-registration binding update must be sent from one of active interfaces attached to foreign links. As a result, the mobile node no longer receives packets at the interface attached to the home link. All packets are routed to other interfaces attached to a foreign link.

5.6. 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 to is no longer available) and MUST be deleted. In such case, the mobile node can not send 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 send 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.

5.7. Receiving Binding Acknowledgment

The verification of a Binding Acknowledgment is the same as in Mobile IPv6 (section 11.7.3 of RFC 3775). The operation for sending a Binding Acknowledgment is described in Section 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 try to discover a new Home Agent supporting the multiple Care-of Address registration or give up with 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 successfully registered the binding information and BID for the mobile node.

If the status code is not zero and Binding Unique Identifier sub-option is in the Binding Acknowledgment, the mobile node proceeds with 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 or SHOULD stop sending Binding Updates with BID.

If the status code is 145, the mobile node should check the status field of Binding Unique Identifier sub-option for the detail information. After correcting errors, the mobile node can re-register only the failed binding in separate registration or bulk registration mode.

5.8. Receiving Binding Refresh Request

The verification of a Binding Refresh Request is the same as in

Mobile IPv6 (section 11.7.4 of RFC 3775). The operation of sending a Binding Refresh Request is described in section Section 6.4.

If a mobile node receives a Binding Refresh Request with a Binding 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.

5.9. 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 RFC 3775. The operation for sending BE is described in the section 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 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. 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. If the priority is available for a binding cache entry, the priority can be used as additional key to search a binding. In the example below, 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]
```

Figure 2: Searching the Binding Cache

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 for 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 does not have a Binding Unique Identifier, the processing of the regular Binding Update is the same as in RFC 3775. 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(s), a receiver node MUST perform additional validations as follows:

- A receiver node MUST validate the Binding Update according to section 9.5.1 of RFC 3775.
- If a Binding Unique Identifier sub-option(s) is present, the receiver node MUST process the sub-option.

- o If the Binding Unique Identifier sub-option is with C flag set and no care-of address is present in the sub-option, the receiver node MUST set 128 in the Status field of the Binding Unique Identifier sub-option and send a Binding Acknowledgment with status code set to 145 with the Binding Unique Identifier sub-option. If either a Correspondent Node or a Home Agent not supporting bulk registration receives the Binding Unique Identifier sub-option with C flag set, it MUST return the error code 146 in a Binding Acknowledgment.

- o 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 C flag is set in the Binding Unique Identifier sub-option, the Care-of Address must be taken from the Care-of Address in the Binding Unique Identifier sub-option.

  - * If the C flag is not set in the Binding Unique Identifier sub-option, the Care-of Address must be taken from the Source Address field of the IPv6 header.

  - * If the C flag is not set and an alternate care-of address is present, the care-of address is taken from the Alternate Care-of Address sub-option.

  - * 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 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 the receiver node found R flag in a Binding Unique

Identifier sub-option, the C flag must be set. Otherwise, it replies with 128 in a Binding Unique Identifier sub-option and set 145 in a Binding Acknowledgment. The receiver node must remove the binding correspondent to the Binding Unique Identifier sub-option for which R flag is set.

- 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 Acknowledgment to the mobile node, in which the Status field is set to 133 (not Home Agent for this mobile node).

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 RFC 3775. Otherwise, whenever the Binding Unique Identifier 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 an 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 RFC 3775. 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 MAY 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 MUST 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 [7]

Issues regarding mobile routers with multiple interfaces and other multihoming configurations are documented in [10].

Since the binding management mechanisms are the same for a mobile host operating Mobile IPv6 and for a mobile router operating NEMO Basic Support (RFC 3963), our extensions can also be used to deal with multiple Care-of Addresses registration sent from a multihomed mobile router.

8. IPsec and IKE interaction

TBA

9. Conclusion

In this document, we propose a solution to achieve multihomed mobile node on Mobile IPv6 and Network Mobility. A binding unique identifier is introduced to register multiple care-of addresses to a Home Agent and a Correspondent Node. Those care-of addresses are bound to the same home address. A few modifications to Mobile IPv6 and NEMO are required to support multiple care-of address registration.

10. Acknowledgments

The authors would like to thank Masafumi Aramoto (Sharp Corporation), Julien Charbon, Susumu Koshiba, Martti Kuparinen (Ericsson), Romain Kuntz (Keio-U), Heikki Mahkonen (Ericsson), Hiroki Matutani (Tokyo-U), Koshiro Mitsuya (Keio-U), Nicolas Montavont, Koji Okada (Keio-U), Keisuke Uehara (Keio-U), Masafumi Watari (KDDI R&D) in alphabetical order, the Jun Murai Lab. at KEIO University, and WIDE project for their contributions.

11. References

11.1. Normative References

[1] Deering, S. and R. Hinden, "Internet Protocol Version 6 (IPv6)", IETF RFC 2460, December 1998.

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

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

[4] Montavont, N., Wakikawa, R., Ernst, T., Ng, C., and K. Kuladinithi, "Analysis of Multihoming in Mobile IPv6", draft-ietf-monami6-mipv6-analysis-00 (work in progress), February 2006.

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

[6] Ernst, T. and H. Lach, "Network Mobility Support Terminology", draft-ietf-nemo-terminology-05 (work in progress), February 2006.

[7] Ernst, T., "Network Mobility Support Goals and Requirements", draft-ietf-nemo-requirements-05 (work in progress), October 2005.

11.2. Informative References

[8] Stemm, M. and R. Katz, "Vertical Handoffs in Wireless Overlay Networks", Journal Mobile Networks and Applications, vol. 3, number 4, pages 335-350, 1998.

[9] Ernst, T., "Motivations and Scenarios for Using Multiple

Interfaces and Global Addresses", draft-ietf-monami6-multihoming-motivation-scenario-00 (work in progress), February 2006.

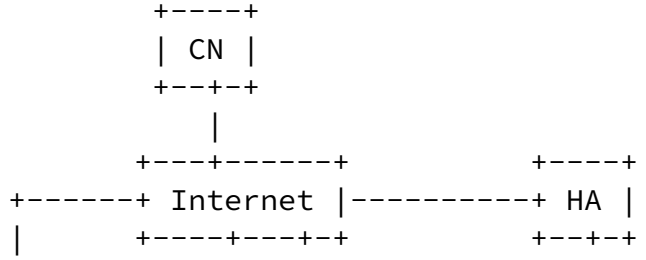
[10] Ng, C., "Analysis of Multihoming in Network Mobility Support", draft-ietf-nemo-multihoming-issues-05 (work in progress), February 2006.

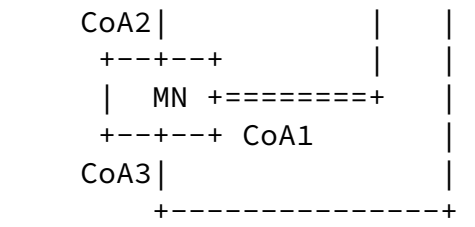
Appendix A. Example Configurations

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 3 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 their binding cache database. The mobile node can utilize all the interfaces.

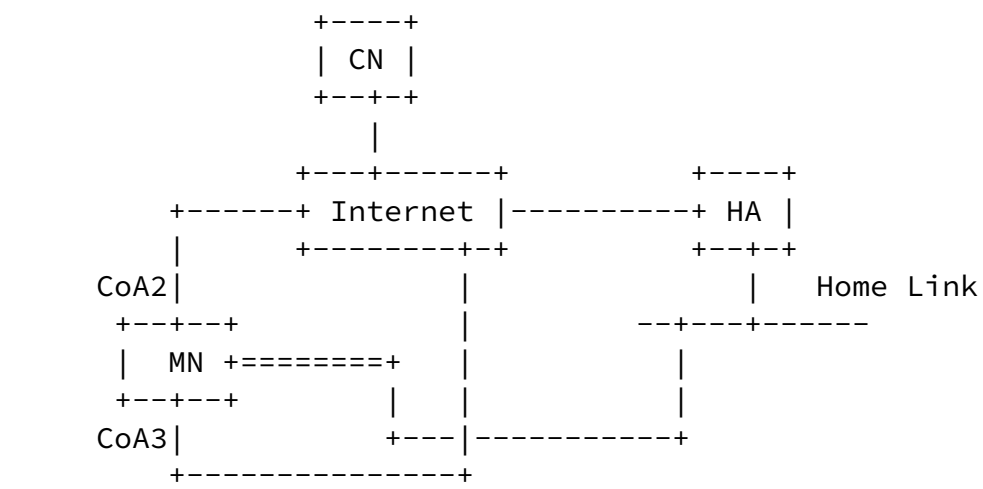





```
  Binding Cache Database:
     Home Agent's binding (Proxy neighbor advertisement is active)
           binding [a:b:c:d::EUI  Care-of Address1  BID1]
           binding [a:b:c:d::EUI  Care-of Address2  BID2]
           binding [a:b:c:d::EUI  Care-of Address3  BID3]
     Correspondent Node's binding
           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 3: Multiple Interfaces Attached to a Foreign Link

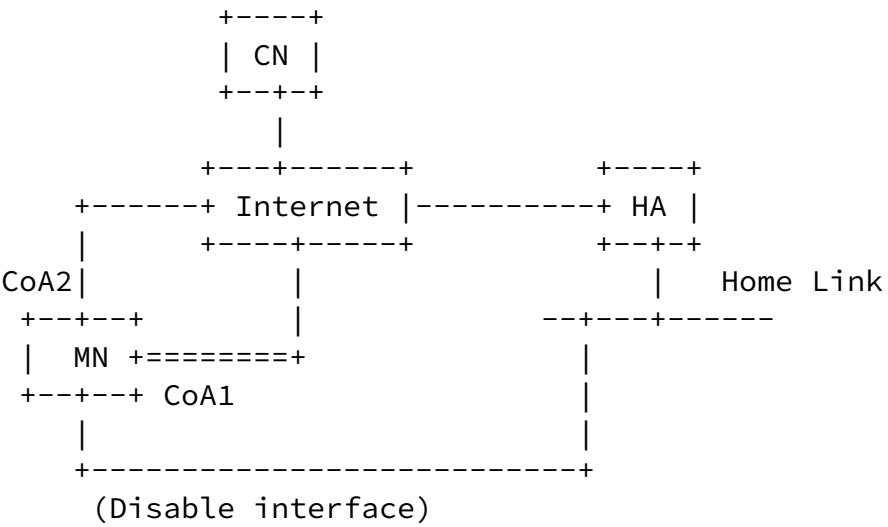
Figure 4 depicts the scenario where MN returns home with one of its interfaces. After the successful de-registration of the binding to HA, HA and CN have the binding entries listed in their binding cache database of Figure 4. MN can communicate with the HA through only the interface attached to the home link. On the other hand, the mobile node can communicate with CN from the other interfaces attached to foreign links (i.e. 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 4: One of Interface Attached to Home Link and Returing Home

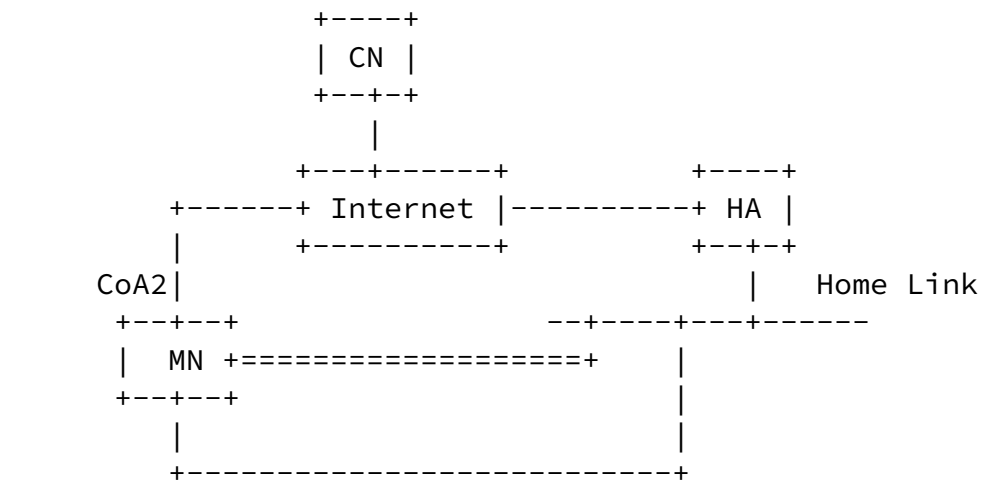
Figure 5 depicts the scenario where MN disables the interface attached to the home link and communicates with the interfaces attached to foreign links. The HA and the CN have the binding entries listed in their binding cache database. MN disable the interface attached to the home link, because the HA 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.




```
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 5: One of Interface Attached to Home Link and Not Returing Home

Figure 6 depicts the scenario where multiple interfaces of MN are attached to the home link. The HA and CN have the binding entries listed in Figure 6 in their binding cache database. The MN can not use the interface attached to a foreign link unless a CN has a binding for the interface. All packets which arrive at the HA are routed to one of the MN's interfaces attached to the home link.




```
  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]
```

Figure 6: Several Interfaces Attached to Home Link and Returning Home

Figure 6 depicts the scenario where interfaces of MN are attached to the foreign links. One of foreign link is managed by the home agent. The HA and CN have the binding entries listed in Figure 6 in their binding cache database. The home agent advertises a prefix which is other than home prefix. The mobile node will generate a care-of address from the prefix and registers it to the home agent. Even if the mobile node attaches to a foreign link, the link is managed by its home agent. It will tunnel the packets to the home agent, but the home agent is one-hop neighbor. The cost of tunnel is negligible. If the mobile node wants to utilize not only an interface attached to home but also interfaces attached to foreign link, it can use this foreign link of the home agent to return home. This is different from the general returning home, but this enable

the capability of using interfaces attached to both home and foreign link without any modifications to Mobile IPv6 and Nemo basic support.

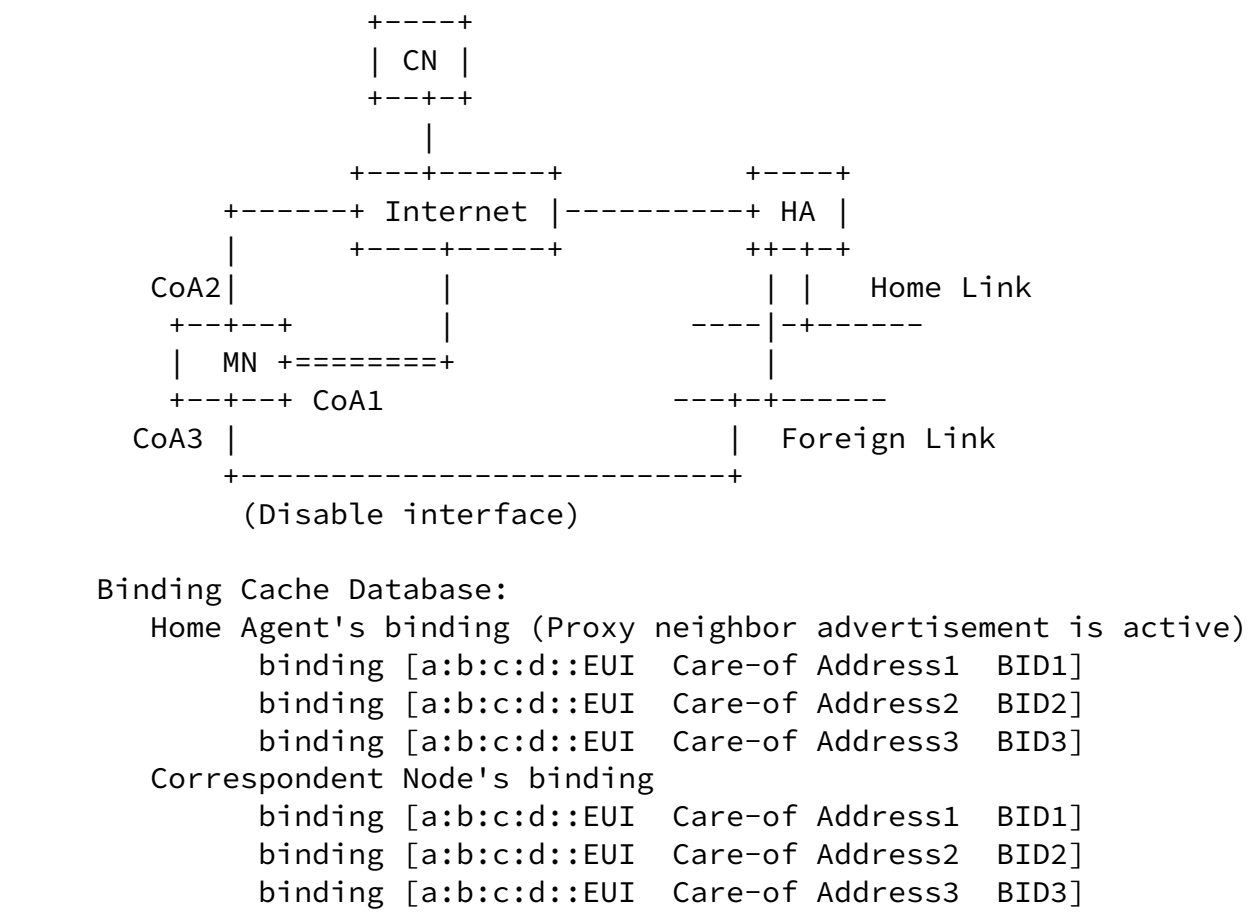


Figure 7: Emulating to Utilize Interfaces Attached to both Home and Foreign Links

Appendix B. Changes From Previous Versions

Changes from draft-wakikawa-mobileip-multiplecoa-05.txt

- Updating packet formats. B flag in Binding Unique Identifier sub-option is removed.
- Updating packet formats. C and R flags in Unique Binding Identifier sub-option are introduced for bulk registration.
- Bulk Registration for home registration is now supported. Bulk Registartion to Correspondent Node is not supported in this document.
- IPsec and IKE interaction will be added shortly.
- The DHAAD extension is removed.

Authors' Addresses

Ryuji Wakikawa
Keio University
Department of Environmental Information, Keio University.
5322 Endo
Fujisawa, Kanagawa 252-8520
Japan

Phone: +81-466-49-1100
Fax: +81-466-49-1395
Email: ryuji@sfc.wide.ad.jp
URI: http://www.wakikawa.org/

Thierry Ernst
Keio University / WIDE
Jun Murai Lab., Keio University.
K-square Town Campus, 1488-8 Ogura, Saiwa-Ku
Kawasaki, Kanagawa 212-0054
Japan

Phone: +81-44-580-1600
Fax: +81-44-580-1437
Email: ernst@sfc.wide.ad.jp
URI: http://www.sfc.wide.ad.jp/~ernst/

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

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

Intellectual Property Statement

on the procedures with respect to rights in RFC documents can be found in BCP 78 and BCP 79.

Copies of IPR disclosures made to the IETF Secretariat and any assurances of licenses to be made available, or the result of an attempt made to obtain a general license or permission for the use of such proprietary rights by implementers or users of this specification can be obtained from the IETF on-line IPR repository at http://www.ietf.org/ipr.

The IETF invites any interested party to bring to its attention any copyrights, patents or patent applications, or other proprietary rights that may cover technology that may be required to implement this standard. Please address the information to the IETF at ietf-ipr@ietf.org.

Disclaimer of Validity

Copyright Statement

Acknowledgment

Funding for the RFC Editor function is currently provided by the Internet Society.