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H. Soliman
Elevate Technologies
N. Montavont
IT/Telecom Bretagne
N. Fikouras
K. Kuladinithi
University of Bremen
May 16, 2008

Flow Bindings in Mobile IPv6 and Nemo Basic Support
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Abstract

This document introduces extensions to Mobile IPv6 [1] and Nemo Basic Support [2] that allow nodes to bind one or more flows to a care-of address. These extensions allow multihomed nodes to take full advantage of the different properties associated with each of their interfaces.

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1. Introduction

Mobile IPv6 (RFC3775) [1] and Nemo Basic Support (RFC3963) [2] allow a mobile node / mobile router to manage its mobility using the binding update message, which binds one care-of address to one home address. The binding update message can be sent to the home agent. In Mobile IPv6, the Binding Update can also be sent to correspondent node or to a mobility anchor point (see RFC4140 [3]). The semantics of the binding update are limited to address changes. That is, RFC3775 [1] and RFC3963 [2] do not allow a mobile node / mobile router to bind more than one address to the home address. Furthermore, the binding granularity is limited to the address. Therefore, a mobile host cannot associate one of the connections using the home address with a different care-of address. In draft-ietf-monami6-multiplecoa [4] Mobile IPv6 and Nemo Basic Support are extended to allow the binding of more than one care-of address to a home address. This specification extends Mobile IPv6 and Nemo Basic Support to allow it to specify policies associated with each binding. A policy can contain a request for a special treatment of a particular flow. Hence, this specification allows a mobile node / mobile router to bind a particular flow to a care-of address without affecting other flows using the same home address. In addition, we will see that this specification allows to bind a particular flow to a particular care-of address directly with correspondent node and mobility anchor point in the case of a single mobile node.

In this document, a flow is defined as one or more connections that are identified by a flow identifier. A single connection is typically identified by the source and destination IP addresses, transport protocol number and the source and destination port numbers. Alternatively a flow can be identified in a simpler manner using the flow label field in the IPv6 header [5] or the Security Parameter Index (SPI) when IPsec is used.

Flow bindings are useful in cases where the mobile node / mobile router has more than one address, probably due to being multihomed, and wants to direct certain flows to certain addresses [6], [7]. This may be done because some flows are better suited to certain link layers or simply to load balance flows between different interfaces. This specification introduces the flow identifier option, which is included in the binding update message and used to distribute policies to the recipient of the binding update. However, this document does not define the flow itself but only the action to take on this flow. The flow description will be defined in another document. This will allow to use the same flow description in several protocols. Using the flow identifier option introduced in this specification a mobile node / mobile router can bind one or more flows to a care-of address while maintaining the reception of other

flows on another care-of address. Requesting the flow binding can be decided based on local policies within the mobile node / mobile router and based on the link characteristics and the types of applications running at the time. Such policies are outside the scope of this document.

It should be noted that the flow identification option can be associated with any binding update, whether it is sent to a correspondent node (in the case of Mobile IPv6), home agent or mobility anchor point (in the case of Hierarchical Mobile IPv6). A Similar mechanism for Mobile IPv4 is described in [8].

In the rest of the document, the term "mobile node" is used to designate either a mobile node as defined in RFC3775 [1] or a mobile router as defined in RFC3963 [2] unless stated otherwise.

2. Terminology

Terms used in this document are defined in [9] and [10]. The following terms are also used in this document:

Flow

A flow is identified as a set of data packets that are exchanged between two distant hosts.

Flow Description

A set of instructions that describes a flow.

Flow Identifier

Identifier of a flow binding.

Flow binding

A mobility binding extended with a flow identifier and flow description.

3. Mobile IPv6 Extensions

This section introduces extensions to Mobile IPv6 that are necessary for supporting the flow binding mechanism described in this document.

3.1. Flow Identification option

The Flow identification option is included in the binding update and acknowledgement messages. This option contains information that allows the receiver of a binding update to install policies on a traffic flow and route it to a given address. Multiple options may exist within a binding update message. The Flow identification option must come with another option (that will be defined in another document) that will describe the flow. This additional option is called Flow Description in the remaining of this document.

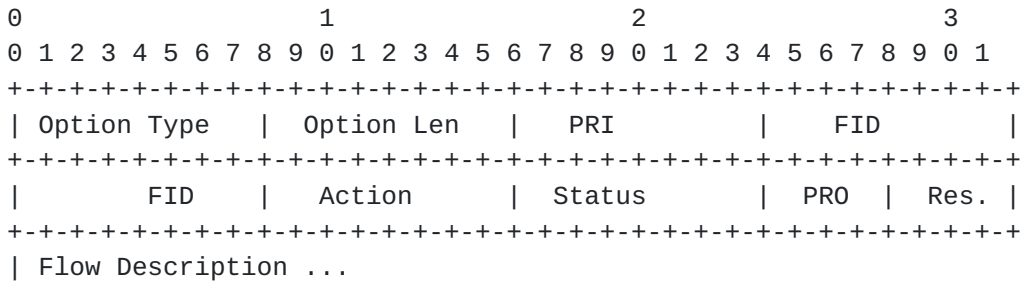


Figure 1: The flow identification option

Option Type

TBD

Option Len

Length of option in 8-octet units

PRI

This is a 8-bit priority field to indicate the priority of a particular option. This field is needed in cases where two different flow descriptions in two different options overlap. The priority field decides which policy should be in those cases. A lower number in this field indicates a higher priority.

FID

The Flow Identifier field is an 8-bit unsigned integer that includes the identifier for the flow binding. This field is used

to refer to an existing binding or to create a new binding.

Action

This field specifies the action that needs to be taken by the receiver of the binding update containing the flow identification option.

Status

This field indicates the success or failure of the flow binding operation for the particular flow in the option. This field is not relevant to the binding update message as a whole or to other flow identification options. Values from 0 to 127 indicate success. Values of 128 and higher indicate failure. This field is only relevant when included in the Binding Acknowledgement message and must be ignored in the binding update message.

PRO

This is a 4-bit field that describes the required processing for the option. This field may indicate a request for adding, deleting, modifying or refreshing the option. The details of these requests are discussed below.

Res.

This field is unused. It MUST be initialized to zero by the sender and MUST be ignored by the receiver.

The following values are reserved for the PRO field in this option:

0 Add a flow binding

1 Replace a flow binding

2 Refresh the current binding

15 Remove a flow binding

The following values are reserved for the Action field in this option:

1 Forward. This value indicates a request to forward a flow to the address included or referred to by the option.

2 Discard. This value indicates a request to discard all packets in the flow described by this option.

3 n-cast. This value indicates a request to replicate the flow to several addresses. If this value is used, one or more Binding Reference sub-options MUST exist. The Binding Reference sub-option is described later in this specification.

The following values are reserved for the status field within the flow identification option:

0 Flow binding successful.

128 Flow binding rejected, reason unspecified.

129 Flow binding option poorly formed.

130 Administratively prohibited.

131 Flow identification by IPv6 prefix is not supported.

132 Flow identification by port numbers is not supported.

133 Flow identification with Flow label is not supported.

134 Flow identification with SPI is not supported.

135 FID already in use

136 FID not found

137 Classifier language not supported.

138 Discard function not supported.

139 N-cast function not supported.

It should be noted that per-packet load balancing has negative impacts on TCP congestion avoidance mechanisms as it is desirable to maintain order between packets belonging to the same TCP connection. This behaviour is specified in RFC2702 [11]. Other negative impacts are also foreseen for other types of real time connections due to the potential variations in RTT between packets. Hence per-packet load balancing is not allowed in this extension. However, the MN can still request per-flow load balancing provided that the entire flow is moved to the new interface.

3.2. The Binding Reference Sub-option

This section introduces the Binding Reference sub-option, which may be included in the Flow identification option. The Binding Reference sub-option includes one or more BIDs as defined in [4]. When this sub-option is included in the Flow identification option it associates the flow described with one or more BIDs that where already registered with the recipient of the BU. A BID sub-option is not necessarily included in the same BU, but MUST be already known to the receiver of the BU. The Binding Reference sub-option is shown below.

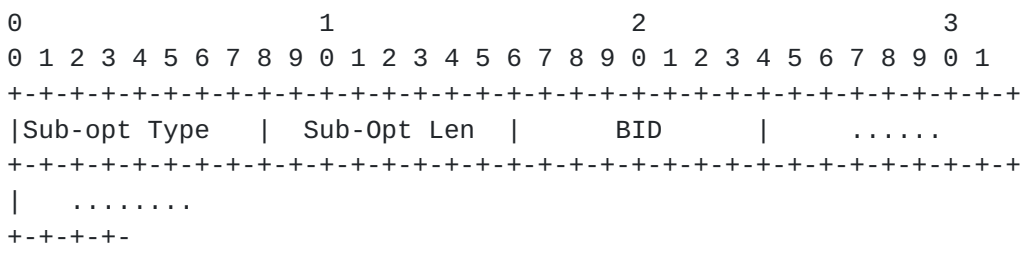


Figure 2: The Binding Reference sub-option

Sub-opt Type

Indicates the Sub-option type. For the Binding Reference sub-option, this field MUST be set to 1.

Sub-opt Len

Indicates the sub-option length in octets. This field includes the entire length of the sub-option including the type and length fields.

BID

The BID that the mobile node wants to associate with the flow identification option. One or more BID fields can be included in this sub-option.

3.3. Binding Cache and Binding Update list extensions

Flow bindings are conceptually stored in Binding Cache of home agent, mobility anchor point and correspondent node, and in Binding Update List of mobile node. These logical structures need to be extended to include the following parameters (in addition to those described in

RFC3775 [1]):

- FID (Flow Identifier). For a given home address, the FID MUST uniquely identify an entry, i.e. a unique flow binding. An FID is only unique for a given home address. Different mobile nodes can use the same FID value.

- Each attribute that constitutes the flow dsecription (and that are defined in a separate document).

An entry in these structures is identified by the couple (home address, FID).

4. Protocol operations

The flow identification option defines the controls on flow bindings. The fields of the flow identification option are necessary for indexing flow identification options, indicating the sort of action that should be undertaken to the recipient's Binding Cache or for carrying the results of such a petition. The flow description is transported in another option that will be defined in another document. This separation is made to use the same flow description in various protocols.

This specification allows mobile nodes to direct flows to a particular care-of address. This can be done by aggregating many flows in the flow identification option (e.g. all TCP traffic), or by uniquely identifying a flow in the flow identification option.

The remaining of this section discusses how mobile nodes can use the flow identification option when sending binding updates to the correspondent node, home agent or mobility anchor point. In addition, deletion and modification of bindings are all discussed below.

4.1. Interaction with the Multiple CoA bindings mechanism

Flow binding presented in this specification MUST be used with the solution in [4]. The main reason why is to avoid the duplication of the default binding to be used when none of the registered rules can apply to a flow. As the multiple CoA bindings document already defines a prority field which indicates which care-of address is preferred, flow binding uses this priority field in order to maintain a primary Care-of address (see below section Section 4.3).

Moreover, combining the mechanism in this specification with the multiple CoA bindings allows for further aggregation of bindings. For example, if a mobile node has several flow identifiers bound to a single Care-of address identified by a unique BID, the mobile node can change the Care-of address for all these flows bindings just by changing the Care-of address associated with the given BID.

Additionally, the combination of the two mechanisms allows for additional features (e.g., n-casting) to take place with minimal effort. Hence, this specification makes use of the BID option described in [4].

4.2. Flow binding storage

Home agent, correspondent node and mobility anchor point maintain Binding Cache in order to record associations between home addresses

and care-of addresses of mobile nodes that are away from the home link. Mobile nodes maintain binding update list to record binding between home address and care-of address. RFC 3775 [1] allows mobile nodes to register only one care-of address per home address. Thus a binding cache entry is uniquely identified by the home address.

This specification extends the binding cache and the binding update list structures, and allows mobile node to (1) register multiple care-of addresses for a given home address and (2) associate flow binding policies with the registered care-of addresses.

New parameters are added to these conceptual structures in order to list the particular rule associated with a standard binding. On one hand, an entry is now identified by the pair (home address, FID) because several Care-of addresses may be bound to a single home address. On the other hand, the Care-of address is selected according to the best match between the packets that need to be sent, and the existing flow bindings. If no matching is found between the flow bindings and the data packet, a preferred entry is used (see next subsection). If a flow matches two different flow bindings, the PRI field indicates which action is preferred by the mobile node.

4.3. Preferred Care-of address

Any distant node which supports the flow identification option MUST maintain a default binding per home address. A default binding indicates an association between a home address and a Care-of address. In addition to the default binding, several bindings may co-exist within a binding cache for the same home address, each of them indicating different bindings between flows and Care-of addresses. When a data flow is intercepted by a home agent or initiated by a correspondent node, if the said data flow does not match an existing flow identification option, the care-of address indicated in the default binding is used as destination address for the mobile node. The default binding is indicated by the Priority field in the BID option described in [4]. A mobile node is responsible for having a preferred care-of address with the receiver of the flow identification option.

4.4. Adding flow bindings

When adding a new flow binding, a mobile node sends the flow identification option in the binding update. The care-of address concerned with this binding update must already be registered by the receiver of the binding update (i.e., must already be associated with a BID), or a BID sub-option MUST be present in the binding update (as defined in [4]). The flow identification option MUST include a unique FID. The FID needs only be unique for the receiver of the

binding update, i.e. the same FID can be used across different receivers of the binding update. The PRO field MUST indicate an Add operation. Adding the flow binding implies associating a flow with a particular care-of address for the mobile node. The care-of address concerned with the flow binding is present in the source address of the packet or the alternate care-of address option. Alternatively, the care-of address may be indicated by the BID (which is pointing to an existing care-of address) when the Binding Reference sub-option of the Flow Identification option is present.

The mobile node may need to define the flow partially or entirely based on the source and destination addresses in packets. For instance, a mobile node may choose to forward all flows from address A to address B to a particular care-of address. Alternatively, more granularity can be added by including port numbers and protocol. These descriptions will be given in another document.

An Add operation implies that the FID is new and is not already used by the mobile node for any other flow binding. If the Flow identification option is sent without any flow description and with the PRO field indicating an Add operation, this MUST be seen as a wild card request by the sender. A wild card request implies that all flows should be directed to the particular care-of address in the packet.

4.5. Modifying flow bindings

When modifying a flow binding (either the care-of address or other attributes of the flow), the mobile node sends the binding update with a flow identification option. The option includes the FID for the binding being modified, as well as the PRO field set to 1, indicating a request to modify the binding. A flow description option may come with the flow identification option and contain the new attributes needed to classify the flow. Hence, flow modification is essentially a process where an existing flow definition is removed and a new flow (included in the option) is added and given the same FID as the flow that was removed.

If one of the care-of addresses needs to be updated with a new one (e.g., after a change of the IP point of attachment), the mobile node may just need to register the new care-of address for the given BID.

4.6. Removing flow bindings

When removing a flow binding, the mobile node sends a binding update message with the flow identification option. The PRO field MUST be set to a value of 15, which indicates a request for removing a flow binding. This will provide enough information for the receiver to

locate the flow binding using the FID and remove it.

4.7. Refreshing Flow Bindings

A flow binding is refreshed by simply including the Flow identification option in the BU message. In this case the PRO field is set to indicate a refresh operation.

The refresh operation is included in this specification due to the nature of the BU message. The BU message updates existing bindings with new information. Hence, all information previously sent in the last BU message need to be resent in all new messages, otherwise such information will be lost.

4.8. Acknowledging flow identification options

The home agent and mobility anchor point are required to ackowledge the reception of Binding Update by sending Binding Acknowledgment. A correspondent node SHOULD also acknowledge Binding Update. The Binding Acknowledgement is extended by this specification to indicate to the mobile node the success of the flow binding. If a Binding Acknowledgement needs to be sent in response to a Binding Update that contained flow identification option(s), a copy of each flow identification MUST be included. Only the Status field needs to be changed to the appropriate value. The absence of flow identification option in Binding Acknwoledgement indicates that the sender does not support the extension descibed in this document and therefore MUST be interpreted as a negative acknowledgement.

5. Usage scenario

In this section, we highlight a use case of the flow identification option.

Assume a mobile node equipped with two interfaces namely If1 and If2, each connected to a different foreign network. The mobile node configures one global IPv6 address on each interface, namely CoA1 and CoA2 respectively. The mobile node runs Mobile IPv6 with a home agent located in its home network. We assume that an existing IPsec security association is set up betweeen the mobile node and its home agent. We assume that the mobile node wants to exchange secure data flows over CoA1 and insecure data flows over CoA2. To do so, the mobile node may request its home agent to redirect packets intended to the mobile node's home address to a different care-of address, depending on the type of the communication. For example, port numbers 22 (ssh) and 443 (https) may be tunneled to CoA1 while other communications may be tunneled to CoA2. In order to set up these flow bindings, the following messages are exchanged:

- The mobile node sends a Binding Update through If2, with the source address set to CoA2. The Binding Update includes a BID sub-option as described in [4]. This sub-option intends to set the highest preference on the given Care-of address.

- When the home agent receives the Binding Update, it first validates the Binding Update as recommanded in section 10.3 of [1]. If the Binding Update is accepted, the home agent processes the BID sub-option as described in section 6.2 of [4]. It then registers the source address of the Binding Update as the preferred care-of address for the given home address and sends back a Binding Acknowledgement.

- Later, the mobile node sends additional Binding Update with both Flow Identification options and BID sub-option of [4]. The BID sub-option is used to indicate the priority of the new Care-of address. In this example, the priority must be lower than the priority of CoA2. The flow identification options are used to indicate the Care-of address usage preferences. In order to redirect source port numbers 22 and 443 to CoA1, two flow identification options need to be transported as well in the Binding Update. These flow identification options are set as follows: PRI is set to 1, Action is set to 0 (forward), PRO is set to 0 (add), FID is set to 1 (and 2 for the second option), and the following flow description option should indicate port number 22 and 443.

- When the home agent receives this second Binding Update, it first checks the validity of the Binding Update as recommanded in section 10.3 of [1] and section 6.2 of [4]. If the Binding Update is accepted, the Flow Identification options are treated. If these options are accepted by the home agent, it will return a Binding Acknowledgement with Flow Identification options, each of them having the same first 8 bytes, and the Status field set to 0 (success).

  Thereafter, if a data flow is destinated to the home address of the mobile node, the home agent will determine if the source port number is equal to 22 or 443. If yes, the home agent will tunnel the data flow to CoA1. If not, the data flow will be forwarded to CoA2.

6. Mobile Node operations

6.1. Default Bindings

A default binding is always maintained between a MN and its peers (home agent, correspondent node if RO is used and mobility anchor point if applicable). The default entry indicates which care-of address to use for a data flow that does not match any of the flow bindings. The preferred care-of address is determined through the BID option described in [4].

6.1.1. Managing Flow Bindings with the Home Agent and MAP

A mobile node may establish a Flow Binding by issuing a Binding Update containing a Flow Identifier (possibly associated with a Flow Description) in its mobility options. The Flow Identification option MUST indicate valid FID, PRO, PRI (rule priority) and Action fields.

The PRO field of the Flow Identification option indicates the processing that the targeted node has to perform to its Bindings Cache List. A mobile node may request for any of the following requests:

- 0: Add flow binding. Create a new Flow Binding with the indicated FID and include the attached Flow. A mobile node MUST NOT issue a Flow Identifier with the PRO field set to zero for an existing FID.

- 1: Replace a flow binding. This request enables the mobile node to replace attributes of the flow or the care-of address associated with the FID. A mobile node MUST NOT issue a Flow Identifier with the PRO field set to one for a non existent FID.

- 2: Refresh a flow binding. This request allows the mobile node to inform the receiver of the BU message that the flow binding is still valid. This request does not modify the flow option. A flow identification option MUST NOT contain this value in the PRO field for a non-existent FID.

- 15: Remove a flow binding. This action enables a mobile node to remove the Flow Binding indicated by the FID on the targeted node. A mobile node MUST not issue a Flow Identifier with the PRO field set to 15 for a non existent FID.

When adding a flow binding on the home agent or MAP, the mobile node MUST ensure the following:

- The PRO field MUST be set to indicate an Add operation.
- The FID field includes a value that does not already exist in the mobile node's binding update list.
- The PRI field is set to indicate the priority of the rule in case of an overlap between rules. An overlap can occur when one flow matches multiple flow description options.
- If the Action field is set to indicate N-cast, the Binding Reference sub-option must be present and it must contain one or more BIDs. If the Binding Update sub-option includes only one BID, it must be pointing to a care-of address other than the one included in the binding update.

6.1.2. Managing Flow Bindings in Correspondent nodes

When route optimisation is used (see RFC3775 [1]), a mobile node sends the BU message to the correspondent node after the return routability test procedure. When adding flow bindings in the BU sent to the correspondent node, the mobile node MUST ensure the following:

- The FID field includes a value that is not already stored in the binding update list with the correspondent node's address.
- The PRO field is set to indicate an Add operation.

A mobile node can also modify or delete flow bindings in a similar manner to that described earlier with the home agent and MAP. When Modifying a flow binding, the mobile node MUST ensure that the FID used already exists. The rest of the rules for modifying flow bindings are the same as those listed above for adding a flow binding.

Refreshing and deleting flow bindings are done in the same manner as that described for the home agent and MAP with one exception: the mobile node MUST NOT refresh or delete bindings associated with any care-of address other than the one included in the BU message.

6.1.3. Using Alternate Care-Of Address

If the Alternate Care-of Address option is used in the Binding Update, it shall indicate the care-of address to be associated with the Flow Identification options. The Flow Identification options shall contain the FID to be allocated to the Flow Binding.

6.1.4. Receiving Binding Acknowledgements

According to [1] all nodes are required to silently ignore mobility options not understood while processing Binding Updates. As such a mobile node receiving a Binding Acknowledgement in response to the transmission of a Binding Update MUST determine if the Binding Acknowledgement contains a copy of the 8 bytes of every Flow Identification options included in the Binding Update. A Binding Acknowledgement without Flow Identification option(s) would indicate inabillity on behalf of the source node to support the extensions presented in this document.

If a received Binding Acknowledgement contains a copy of the 8 bytes of each flow identification option that was sent within the Binding Update, the status field of each flow identification option indicates the status of the flow binding on the distant node.

6.2. Movement

When a MN changes its point of attachment to the Internet, its Care-of address(es) may become invalid and need to be updated. All the flow bindings that are attached to such an old Care-of address need to be udpated with a new Care-of address. This can be achieved by adding flow identification options in Binding Update. One flow identification is needed per flow binding. The flow description may not be needed if only the Care-of address is changed, and not the filter itself. The FID must be set to the flow binding that needs to be udpated and the PRO field MUST be set to 1 (i.e., MODIFY).

Another solution is to take advantage of the multiple care-of addresses bindings [4] to aggregate updates; the mobile node may only need to update the care-of address associated with the given BID. This would avoid to send a flow identification option per flow binding.

6.3. Return Routability Procedure

A mobile node may perform route optimization with correpondent nodes. Route optimization allows a mobile node to bind a care-of address to a home address in order to allow the correspondent node to direct the traffic to the current location of the mobile node. Before sending a Binding Update to correspondent node, the Return Routability Procedure needs to be performed between the mobile node and the correspondent node.

This procedure is not affected by the extensions defined in this document. However, since a Binding Update message is secured with the key generated based on the home address and care-of address test,

a mobile node MUST NOT bind a flow to a care-of address whose keygen token (see RFC3775 [1]) was not used to generate the key for securing the Binding Update. This limitation prohibits the sender from requesting the n-cast action before having registered each care-of address one by one.

6.4. Returning Home

Whenever a mobile node acquires a point of attachment to the home network and wishes to abolish all Flow Bindings associated with the respective home address, it is required to act as described in Section 11.5.4 of RFC3775 [1]. This will cause the home agent to remove all bindings that are linked to the home address, including the flow bindings.

7. Applicability to Route Optimization

The route optimization is only defined for mobile nodes (RFC3775 [1]), and not mobile router (RFC3963 [2]). Thus, this section does not apply to mobile routers. This section describes the correspondent node operations.

Every correspondent node is required to maintain a Binding Cache containing records of associations between mobile node home addresses and care-of addresses (bindings) as they roam away from the home network. RFC3775 [1] allows mobile nodes to register only a single binding per home address with each correspondent node.

This specification extends the binding cache structure, and enables correspondent nodes to (i) maintain multiple bindings for a given home address and (ii) to associate multiple Flow Identification / description options with every binding, termed as Flow Binding. A flow matching a Flow Description should be directed to the Care-of address indicated by the Flow Binding.

7.1. Receiving Binding Udpate

When a correspondant node receives a Binding Update, it first performs the same operation as defined in RFC3775 [1]. If the Binding Update is valid and contains a Flow identification option, the correspondent node needs to check the content of the PRO field. If the PRO field contains a value indicating a request to add a new flow binding, the following checks are done:

- The FID field needs to contain a value that does not already exist. If the FID contains a value that already exists, the correspondent node MUST reject the option by sending that option back in its Binding Acknowledgement with a Status field that contains an error value.

- If the Action field indicates a request to n-cast the flow, the correspondent node MUST reject the option by sending the option in its binding acknowledgement with an appropriate error code.

- If both the FID and Action fields are valid, the correspondent node checks the flow description that must follow the flow identification option. If all of the checks above indicated a valid option, the correspondent node should add the flow binding to its binding cache.

If the PRO field in the option indicates a request to modify the option, the following checks must be done by the correspondent node:

- The FID MUST include a value that already exists. If the FID cannot be found in the correspondent node's binding cache, the flow identification option MUST be rejected with an appropriate error code.

- If the Action field indicates a request to n-cast the flow, the correspondent node MUST reject the option by sending the option in its binding acknowledgement with an appropriate error code.

- If the Binding Reference sub-option is present, the correspondent node MUST ensure that the BID points to the care-of address in the packet, or to an already authrozied care-of address. Otherwise the option MUST be rejected with an appropriate error code.

- If all of the above checks returned a valid result, the correspondent node should modify the binding as requested.

If the PRO field in the option contains a request to refresh a binding, the correspondent node MUST ensure that the FID already exists. If the FID does not exist, the correspondent node MUST reject the option by sending it back in its binding acknowledgement with an appropriate error code in the status field. Otherwise, if the FID exists, the correspondent node must keep it in its binding cache. No further checks need to be done in the option.

The correspondent node should reply with a Binding Acknowledgement message. This Binding Acknowlegement message must contain a copy of the 8 bytes of each flow identification option that was included in the Binding Udpate. The Status field of each Flow Identification option MUST be set to an appropriate value.

8. Home Agent operations

This specification allows the home agent to maintain several bindings for a given home address and to direct packets to different care-of addresses according to flow bindings. This section details the home agent operations necessary to implement this specification.

8.1. Receiving Binding Update with the Flow Identification option

When the home agent receives a Binding Update which includes at least one Flow Identification option, it first performs the operation described in section 10.3.1 of RFC3775. If the Binding Update is accepted, the home agent then checks the flow identification option. If the PRO field in the option indicates an Add operation, the following checks must be done:

- The FID field needs to contain a value that does not already exist. If the FID contains a value that already exists, the home agent MUST reject the option by sending that option back in its Binding acknowledgement with a Status field that contains an appropriate error value.

- If the FID field is valid, the home agent then checks the Action field. If the Action field contains a request for n-cast and the Binding Reference sub-option is not included in the option, the flow binding MUST be rejected in the binding acknowledgement containing an error code in the Status field.

- If both of the checks above indicate valid FID and Action fields, the home agent checks the flow description following the flow identification option, and identifies the filter that needs to be set up.

- If the flow option includes an action field that requests n-casting, the home agent MUST check for the presence of the BID sub-option(s). If the sub-options are not present, the flow identification option MUST be rejected as a poorly formatted option. If one or more BIDs are present in the BID Reference sub-option, the home agent needs to create multiple logical entries in its binding cache. All flows matching the one in the option would be n-cast to the care-of addresses pointed to by the BIDs or the set of registered care-of addresses. If only one BID were included in the Binding Reference sub-option and it pointed to a different care-of address from the one included in the packet, then packets matching the flow would be bicast to those two addresses. However, if only one BID is present and points to the same address in the BU, the n-cast is essentially pointing to one address and therefore cannot be performed. Such option MAY be

rejected as a poorly formatted option.

- o If all of the checks above indicated a valid option, the home agent should add the flow binding to its binding cache.

If the PRO field in the option contains a value indicating a request to modify an existing binding, the following actions must be taken:

- o The FID MUST include a value that already exists. If the FID cannot be found in the home agent's binding cache, the flow identification option MUST be rejected as a poorly formed option.

- o If the FID is valid, the home agent MUST perform the same steps described above for the Add operation.

If the PRO field indicates a refresh operation, the home agent MUST ensure that the FID in the option already exists. If the FID field did not exist, the option MUST be rejected as a poorly formed option. If the FID existed, the home agent MUST keep the current flow binding in its binding cache.

8.2. Sending Binding Ackowledgement

Upon the reception of a Binding Update, the home agent is required to send back a Binding Acknowledgment. The status code in the Binding Acknowledgement must be set as recommanded in [1] and is not modified by the extension defined in this specification. This status code does not give information on the success or failure of the flow binding.

In order to inform about the status of the flow binding that was requested by a mobile node, a flow identification option MUST be set in the Binding Acknowledgement message. The home agent must copy the 8 octets of each Flow Identification option received in the Binding Update and set the status code to an approriate value. Each option must be included in the Binding Acknowledgement message.

8.3. Deleting an entry in the binding cache

A home agent might delete an entry in its binding cache for two reasons: either an entry expires, or the MN explicitly requests the home agent to remove a specific entry. If an entry is going to expire, the home agent SHOULD send a Binding Refresh Advice.

8.3.1. Removing Flow Bindings

If the home agent receives a valid Binding Update with a flow Identification option where the PRO field is set to 15 (Remove), the

home agent MUST remove the corresponding entry. The home agent looks up the entry corresponding to the FID of the Binding Update. If an entry is found, the entry is removed from the Binding cache and a Binding Acknowledgement is sent back to the mobile node with a success value for the status of the flow Identification option (see section Section 8.2. This operation does not modify any other binding that may appear with the same home address. If the FID is not present in the binding cache entry for the corresponding home address, the home agent MUST send back to the mobile node a Binding Acknowledgement with error code 137 (FID not found) in the flow identification option.

9. Applicability to Hierarchical Mobile IPv6

This section describes the Mobility Anchor Point (MAP) operations. The MAP operation is the same as the home agent operation. Flow bindings sent to the MAP are associated with the regional care-of address.

When a MAP receives a Binding Update that includes the flow Identification option, it checks if such option is valid according to the requirements in Section 8.1. If the option is valid, the MAP installs the flow binding associated with the flow identified by the flow description. The lifetime of the binding is the lifetime of the Binding Update. Once the binding is successfully installed, the MAP sends the binding acknowledgement and includes the flow Identification option. The MAP sets the status field to a value indicating success.

In all cases, a flow identification option SHOULD be included in the Binding Acknowledgement to indicate success or failure of the flow binding installation.

10. Security considerations

This draft introduces a new option that adds more granularity to the Binding Update message. The new option allows the mobile node to associate some flows to an interface and other flows to another interface. Since the flow Identification option is part of the mobility header, it uses the same security as the Binding Update, whether it is sent to the home agent, correspondent node, or MAP.

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Authors' Addresses

Hesham Soliman
Elevate Technologies

Phone:
Email: Hesham@elevatemobile.com
URI:

Nicolas Montavont
IT / Telecom Bretagne
2, rue de la chataigneraie
Cesson Sevigne 35576
France

Phone: (+33) 2 99 12 70 23
Email: nicolas.montavont@telecom-bretagne.eu
URI: http://www.rennes.telecom-bretagne.eu/~montavont/

Nikolaus A. Fikouras
University of Bremen
ComNets-ikom,University of Bremen.
Otto-Hahn-Allee NW 1
Bremen, Bremen 28359
Germany

Phone: +49-421-218-8264
Fax: +49-421-218-3601
Email: niko@comnets.uni-bremen.de
URI: http://www.comnets.uni-bremen.de

Koojana Kuladinithi
University of Bremen
ComNets-ikom,University of Bremen.
Otto-Hahn-Allee NW 1
Bremen, Bremen 28359
Germany

Phone: +49-421-218-8251
Fax: +49-421-218-3601
Email: koo@comnets.uni-bremen.de
URI: http://www.comnets.uni-bremen.de/~koo/

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