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Flow Binding Support for Mobile IPv4
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Abstract

This specification defines extensions to Mobile IPv4 protocol for allowing a mobile node with multiple interfaces to register a care-of address for each of its network interfaces and to simultaneously establish multiple Mobile IP tunnels with its home agent. This essentially allows the mobile node to utilize all the available network interfaces and build an higher aggregated data pipe with the home agent for its home address traffic. Furthermore, these extensions also allow the mobile node and the home agent to negotiate flow policies for binding individual traffic flows with the registered care-of addresses.

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1. Introduction

With the ubiquitous availability of wireless networks supporting different access technologies, mobile devices are now equipped with multiple wireless interfaces and have the ability to connect to the network over any of those interfaces and access the network. It is desirable for the mobile node to leverage all the available network connections for accessing network services.

The operation defined in the Mobile IP Protocol [RFC5944], allows a mobile node to continue to use its home address as it moves around the internet. Based on the mode of operation, there will be a tunnel that will be set up between the home agent and the mobile node, or between the home agent and the foreign agent where the mobile node is attached. In both of these modes, there will only be one interface on the mobile node that is receiving the traffic from the home agent. However, this is not efficient and requires an approach where the mobile node can use more than one interfaces for reaching the home network. The objective being efficient use of all available links to obtain higher aggregated bandwidth for the tunneled traffic between the home agent and the mobile node.

This specification defines extensions to Mobile IPv4 protocol for allowing a mobile node with multiple interfaces to register a care-of address for each of its network interfaces and to simultaneously establish multiple Mobile IP tunnels with its home agent. Furthermore, this specification also defines extensions to allow the mobile node and the home agent to optionally negotiate flow policies for binding individual traffic flows with the registered care-of addresses.

2. Conventions & Terminology

2.1. Conventions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

2.2. Terminology

All the mobility related terms used in this document are to be interpreted as defined in [RFC5944] and [RFC3753]. In addition this document uses the following terms.

Binding Identifier (BID)

It is an identifier for a specific binding of a mobile node. A mobile node, when it registers multiple bindings with its home agent using different care-of addresses, each of those bindings are given a unique identifier and this identifier is called the binding identifier. The identifier is unique within all the bindings for a given mobile node.

Flow Identifier (FID)

It is an identifier for a given IP flow, uniquely identified by source address, destination address, protocol type, source port and destination port.

3. Overview

This document presents extensions to the Mobile IP protocol for allowing a mobile node to register multiple care-of addresses over which it can be reachable. Each of the registered care-of address will be identified by a unique binding identifier (BID). There will be multiple tunnels between the mobile node and the home agent, one tunnel for each of the registed bindings. These multiple tunnel paths can be used for load balancing the mobile node's home address traffic based on the negotiated traffic policies. The extensions specified in this document additionally allow the mobile node and the home agent negotiate flow policies for binding individual traffic flows to the registered care-of addresses. In the absence of any negotiated traffic policies, these multiple tunnel paths appear to the home agent and the mobile node as alternate routing paths and the default IP forwarding behavior of per-flow load balancing will leverage all the available wireless links and will result in a larger aggregated egress traffic throughput.

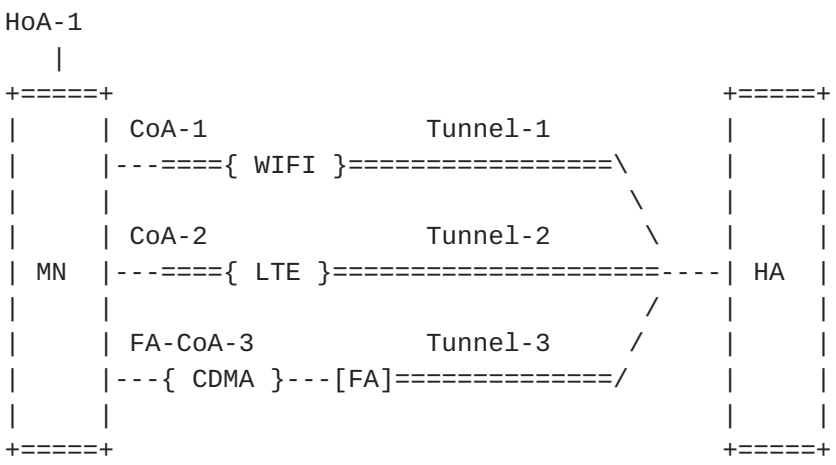


Figure 1: Mobile Node with multiple tunnels to the home agent

Figure 1, illustrates a mobile node attached to the network over three different access technologies, WiFI, LTE and CDMA. The mobile node is assigned home address, HoA-1, has care-of addresses CoA-1, CoA-2 and CoA-3 and has established tunnels Tunnel-1, Tunnel-2 and Tunnel-3 with its home agent.

Flow Id	CoA/Tunnel/BID	Negotiated Flow Policy
1.	CoA-1/Tunnel-1/BID-1	All SIP Flows over WiFI
2.	CoA-2/Tunnel-2/BID-2	All HTTP Flows over LTE value
3.	CoA-3/Tunnel-3/BID-3	All SSH Flows over CDMA

Table 1: Flow Binding Table

The above table is an example of how the individual flows are bound to different care-of addresses registered with the home agent.

4. Message Extensions

This specification defines the following new extensions.

4.1. Alternate-CoA Extension

A new skippable extension to the Mobile IPv4 header in accordance to the short extension format of [RFC5944] is defined here. This extension is for requesting the home agent to register the care-of address present in this extension as one of the alternate care-addresses through which the mobile node can be reached.

This extension MAY be added to the Registration Request only by the mobile node. This extension MUST NOT be added by the home agent or by the foreign agent either to the Registration Request or to the Registration Reply. There can be more than one instance of this extension present in the message.

This extension should be protected by Mobile Home Authentication extension [RFC5944]. As per Section 3.2 and 3.6.1.3 of [RFC5944], the mobile node MUST place this Extension before the Mobile-Home Authentication Extension in the registration messages, so that this extension is integrity protected.

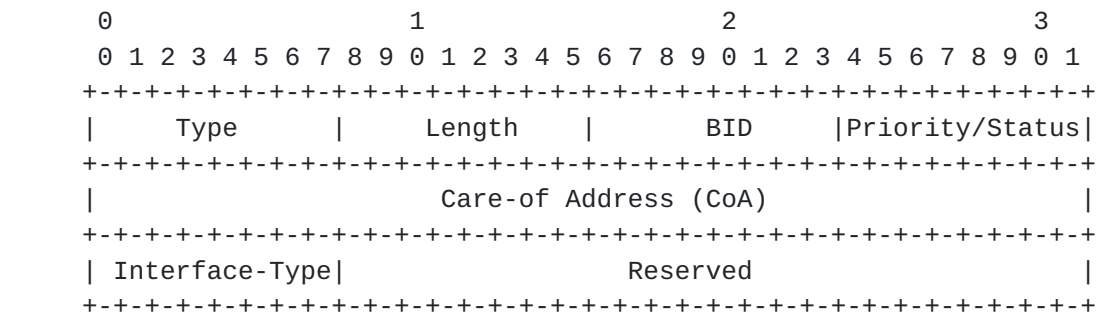


Figure 2: Alternate-CoA Extension

Type

Alternate-CoA Extension (skippable type range to be assigned by IANA)

Length

Indicates the length (in bytes) of the extension. The length does NOT include the Type and Length bytes.

BID (Binding ID)

The BID field in an 8-bit unsigned integer that identifies the binding to the CoA included in this extension and it can be used to point to an Alternate-CoA that was registered earlier.

Priority/Status

When this extension is in a Registration Request this field specifies the priority field assigned to the care-of address. The Priority field is an 8-bit unsigned integer. The receiver can utilize this priority to determine the preference of the CoA used to deliver packets. The lower the value the higher priority. A value of 255 indicates that the CoA indicated should be deregistered.

When this extension is in a Registration Reply this field indicates the status of the CoA. The Status field is an 8-bit unsigned integer. The possible status codes are listed in Table 2.

For the Status field values 0-127 indicate success and values between 128 and 255 indicate failure. The following values are defined for the Status field:

Status	Value	Comments
Accepted	0	The CoA is registered
BID Changed	1	The BID associated with an existing CoA was changed to the new value
Reject	128	The CoA is rejected
Unknown BID	129	The BID was not recognized

Table 2: Values for the Alternate-CoA Status field

Care-Of Address (CoA)

The CoA field is an 32-bit ipaddr. Set to an alternative care-of address to the one included in the Registration Request header. This field may not be included if the extension is included in a Registration Request and if the BID field is set to the BID of CoA registered earlier. In addition this field may not be included if the extension is included in a Registration Reply message.

Interface Type

Type of interface through which the mobile node is connected. The permitted values for this are from the Access Technology Type registry defined in [RFC5213].

Reserved

This field is unused for now. The value MUST be initialized to 0 by the sender and MUST be ignored by the receiver.

4.2. Flow Identification Extension

A new skippable extension to the Mobile IPv4 header in accordance to the short extension format of [RFC5944] is defined here. This extension is included in the Registration Request and Registration Reply messages. This extension contains information that allows the home agent to identify a traffic flow and route it to a given address. There can be more than one instance of this extension present in the message.

This extension should be protected by Mobile Home Authentication extension [RFC5944]. As per Section 3.2 and 3.6.1.3 of [RFC5944], the mobile node MUST place this Extension before the Mobile-Home Authentication Extension in the registration messages, so that this extension is integrity protected.

A Flow Identification extension is designed to populate and edit a mobile node classifier in the home agent. A classifier selects packets based on the content of packet headers according to defined rules. The Flow Identification extension defines a line in such a classifier.

The Flow Identification extension has a flexible format that allows different fields to appear in the extension based on the way the mobile node chooses to represent the flow. The flags following the length field indicate which of the fields used to identify the flow are present in the extension. As a result, there is no fixed format for the flow identification extension. This may result in slight complexity in the implementation; however, this extension will minimize the total length of the extension sent, which is particularly important for bandwidth-limited wireless links.

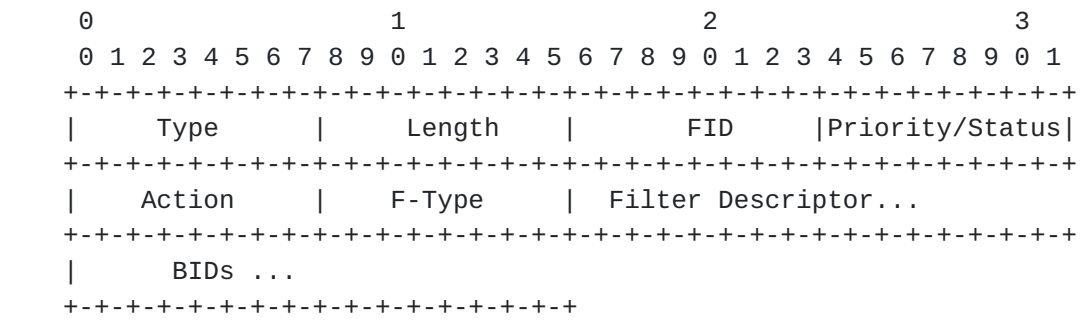


Figure 3: Flow Identification Extension

Type

Flow Identification Extension (skippable type range. Two values to be assigned for IPv4 and IPv6 by IANA)

Length

Indicates the length (in bytes) of the extension. The length does NOT include the Type and Length bytes.

FID

The Flow Identifier field is an 8-bit unsigned integer identifying a flow. This field is used to refer to an existing flow or to identify a new flow.

Priority/Status

The Priority field is an 8-bit unsigned integer. When this extension is in a Registration Request this field specifies the priority field assigned to the filter rule defined by this extension. The receiver can utilize this priority to determine the order of application of the filter rules defined by the sender. The lower the value the higher priority (i.e., it is checked earlier against each packet). A value of 255 indicates that the filter rule indicated should be deregistered.

The Status field is an 8-bit unsigned integer. When this extension is in a registration reply this field indicates the status of the filter rule. The possible status codes are listed in Table 3.

For the Status field values 0-127 indicate success and values between 128 and 255 indicate failure. The following values are defined for the Status field:

Status	Value	Comments
Accepted	0	Flow binding successful
Reject	128	Flow binding rejected, reason unspecified.
Poorly Formed	129	Flow Identification extension poorly formed
Admin Prohibited	130	Administratively prohibited
Unknown FID	131	The FID is not recognized
Unknown BID	132	A BID included in the extension is not registered.

Table 3: Values for the Flow Identification Status field

Action

When this extension is in a Registration Request this field specifies the action that needs to be taken by the receiver. The field SHOULD be set to zero by the home agent in the registration reply and SHOULD be ignored by the mobile node. See defined values in Table 4.

The following values are reserved for the Action field.

Action	Value	Comments
Drop	0	Drop matching packets. A filter rule indicating a drop action MUST include a single BID byte, the value of which MAY be set to 255 by the sender and the value of which SHOULD be ignored by the receiver.
Forward	1	Forward matching packets to the 1st BID in the list of BIDs the filter rule is pointing to. If the 1st BID becomes invalid (i.e., the corresponding CoA is deregistered) use the next BID in the list.
X-Cast	2	Forward one copy of each matching packet to the list of BIDs this filter rule is pointing to.

Table 4: Values for the IPv4 and IPv6 Flow Descriptor Action field

F-Type

The Filter Type (F-Type) field identifies the type of Filter Descriptor included in the extension. Filter Descriptors in addition to the ones defined in this document can be defined in other documents but all Filter Descriptors MUST indicate their own length.

The following values are defined.

F-Type	Value	Comments
Do not Change	0	The already registered filter for the FID of the extension must be used
IPv4 Filter	1	An IPv4 Filter Descriptor follows, see Figure 4
IPv6 Filter	2	An IPv6 Filter Descriptor follows, see Figure 5

Table 5

Filter Descriptor

The Filter Descriptor field defines a filter. This field is further defined in Figure 4 and in Figure 5 depending on the value of the F-Type field of this extension.

BIDs

Indicates the BIDs to which the Filter Rule Descriptor points to, in order of appearance. Note that if a filter rule does not point to any valid BIDs, the filter rule itself becomes invalid.

BID	Value	Comments
Do not Change BID	0	The already registered filter for the FID of the extension must be used
	1-254	These values point to one of BIDs registered with Alternate-CoA extension, in order of appearance. Multiple BID bytes can be included to point to more than one BIDs
Default List	255	the default set of BIDs, registered with Alternate-CoA extensions MUST be used

Table 6

If the Type field of the Flow Identification extension indicates an IPv4 Flow then the Filter Rule Descriptor is as specified below. This fields in the message are identical to the format specified in Section 3.1 of [RFC6088]. Please refer to that document for parameter description.

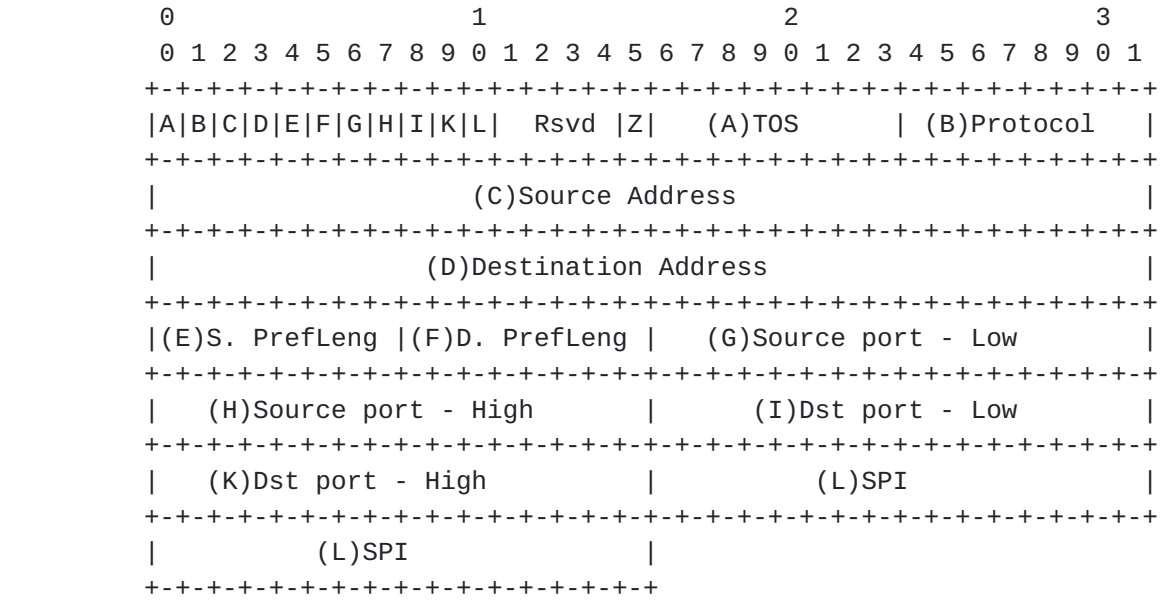


Figure 4: IPv4 Filter Rule Descriptor

Flags (A-L)

Each flag indicates whether the corresponding field is present in the message

(A)TOS - Type of Service

The TOS field in the data packet as seen by the home agent.

(B)Protocol

An 8-bit unsigned integer representing the value of the transport protocol number associated with the port numbers in data packets.

(C)Source Address

This field identifies the source address of data packets as seen by the home agent that is, the 32-bit IPv4 address of the correspondent node.

(D)Destination Address

This field identifies the destination address of data packets as seen by the home agent. When included this field must be set to one of the registered home addresses of the mobile node. It is a 32-bit IPv4 address.

(E)Source Prefix Length

This field includes the prefix length for the source address. This field can only be included if the Source Address field is included.

(F)Destination Prefix Length

This field includes the prefix length for the destination address. If The Destination Address field is included then it refers to that field; otherwise it refers to the home address field of the Registration Request header.

(G)Source Port - Low

This field identifies the lowest source port number within a range of port numbers that will be used in data packets, as seen by the home agent.

(H)Source Port - High

This field identifies the highest source port number within a range of port numbers that will be used in data packets, as seen by the home agent. If a single port is indicated then this field SHOULD NOT be included. If it is included it SHOULD be set to the value of the Source Port ? Low field.

(I)Destination Port - Low

This field identifies the lowest destination port number within a range of port numbers that will be used in data packets as seen by the home agent.

(K)Destination Port - High

This field identifies the highest destination port number within a range of port numbers that will be used in data packets as seen by the home agent. If a single port is indicated then this field SHOULD NOT be included. If it is included it SHOULD be set to the value of the Dst Port ? Low field.

(L)SPI - Security Parameter Index

The SPI field in the data packet as seen by the home agent.

If the Type field of the Flow Identification extension indicates an IPv6 Flow then the Filter Rule Descriptor is as as specified below. The fields in the message are identical to the format specified in Section 3.2 of [RFC6088]. The descriptor format is presented below for convenience.

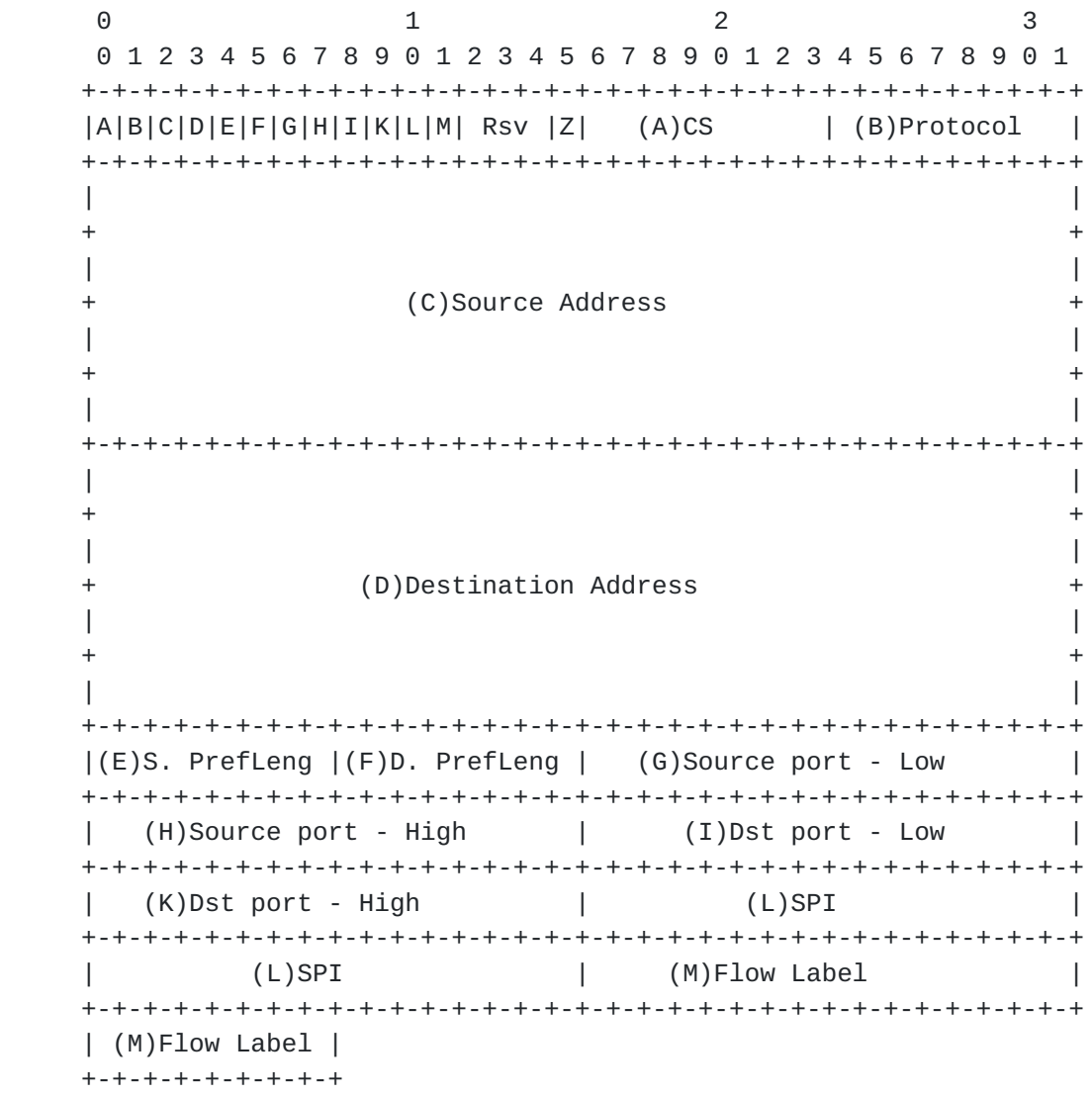


Figure 5: IPv6 Filter Rule Descriptor

Flags (A-M)

Each flag indicates whether the corresponding field is present in the message

CS - Class of Service

The CS field in the data packet as seen by the home agent.

(B)Protocol

An 8-bit unsigned integer representing value of the transport protocol number associated with the port numbers in data packets.

(C)Source Address

This field identifies the source address of data packets as seen by the home agent. That is, the address of the correspondent node and it is a 128-bit IPv6 address.

(D)Destination Address

This field identifies the destination address of the data packet as seen by the home agent. When included this field must be set to one of the registered home addresses of the mobile node and it is a 128-bit IPv6 address.

(E)Source Prefix Length

This field includes the prefix for the source address. This field can only be included if the Source Address field is included .

(F)Destination Prefix Length

This field includes the prefix for the destination address. If The Destination Address field is included then it refers to that field otherwise it refers to the home address field of the registration request header.

(G)Source Port - Low

This field identifies the lowest source port number within a range of port numbers that will be used in data packets, as seen by the home agent.

(H)Source Port - High

This field identifies the highest source port number within a range of port numbers that will be used in data packets, as seen by the home agent. If a single port is indicated then this field SHOULD NOT be included. If it is included it SHOULD be set to the value of the Source Port ? Low field.

(I)Destination Port - Low

This field identifies the lowest destination port number within a range of port numbers that will be used in data packets as seen by the home agent.

(K)Destination Port - High

This field identifies the highest destination port number within a range of port numbers that will be used in data packets as seen by the home agent. If a single port is indicated then this field SHOULD NOT be included. If it is included it SHOULD be set to the value of the Dst Port ? Low field.

(L)SPI - Security Parameter Index

The SPI field in the data packet as seen by the home agent.

(M)Flow Label

The Flow Label field in the data packet as seen by the home agent.

5. Protocol Operation

This specification allows a mobile node to register multiple CoAs using the Alternate-CoA extension and associate different flows with different CoAs by using the Flow Identification extension.

When multiple CoAs are registered without any specific flow associated with them, the registered CoAs are treated as alternative paths to the mobile's current location. The CoAs are ranked by the Priority field in the Alternate-CoA extension and all traffic to the mobile's registered HoA(s) SHOULD be sent to the CoA with the lowest priority. If a CoA is deregistered, the CoA with the next lowest priority SHOULD become the default path for the mobile's traffic.

Note that, the HA MAY be configured with a local policy that takes advantage of multiple CoAs in a certain way. For example, x-casting across the registered CoAs MAY be used by the HA without any further signaling from the mobile; this is a configuration issue and outside the scope of this document.

When the Flow Identification extensions are also used, however, the mobile can indicate which flow is to be associated with which CoA. A single flow MAY be associated with more than one CoAs, while many flows MAY be associated with the same CoA. The effect of associating flows with CoA ofcourse depends on the action defined for that flow.

The Flow Identification extension is variable length and several fields might be omitted as required. When the extension is sent to deregister a filter rule (Priority set to 255) only the first line of Figure 3 needs to be sent (i.e., the first 4 bytes). If the priority and/or action values need to be changed for an existing FID then the F-Type MUST be set to 0 and one BID byte set to 0 MUST be included, indicating no changes to the filter and the BIDs associated with it. The Filter Descriptor of a given FID can be changed by sending the

extension including the new Filter Desctriptor and a single BID byte set to 0. The BIDs associated with a given FID can be changed by sending the extension with F-Type set to 0 (and not including a Filter Descriptor). The F-Type (when not set to 0) indicates the type of Filter Descriptor used. In this specification we define Filter Descriptors for IPv4 and IPv6; other Filter Descriptors MAY be defined in separate documents.

5.1. Mobile Node Considerations

A mobile MAY send an Alternate-CoA extension with the CoA field matching the CoA field in the Mobile IP message header to check whether the HA supports the extensions defined in this specification. Since the extensions defined here are skippable, if the registration reply does not include the Alternate-CoA extensions sent by the mobile, the mobile knows that the HA does not support this specification. If, however, the HA returns the Alternate-CoA extensions in the reply, the HA does support this specification.

5.1.1. Using the Alternate-CoA extension

A mobile MAY include one or more Alternate-CoA extensions in each Registration Request message. If the mobile has already registered a CoA without using the Alternate-CoA extension and the mobile wants to registered an additional CoA, the original and the new CoAs MUST be sent in the new registration as Alternate-CoA extensions so that they can be ranked with priorities and be associated with BIDs. In other words the new message will include an Alternate-CoA with the CoA field set to the CoA registered in the earlier message.

Unless multiple Alternate-CoA extensions are included in the same Registration Request message, the different CoAs will have different lifetimes associated with them. Each CoA MAY be refreshed individually by sending a Registration Request with that CoA in an Alternate-CoA extension. Alternatively, multiple CoAs can be refreshed at the same time by sending a Registration Request with multiple Alternate-CoA extensions.

If an earlier registered CoA is not included in a Registration Request it does not mean that the CoA is deregistered. Instead CoAs are deregistered when their lifetimes expire or when they are explicitly deregistered by the mobile node.

A mobile MAY deregister any CoA by setting its priority to 255. Note that the mobile can change the priority of a given CoA by sending an Alternate-CoA extension with the BID field set to the BID of the CoA in question, the priority field to the new value (or 255 for deregistration), and without including the CoA field.

A mobile MAY replace the CoA associated with a given BID by sending an Alternate-CoA with the BID field set to the BID of an existing CoA and the priority and CoA fields to their new values.

5.1.2. Using the Flow Identification Extension

The Flow Identification extensions allow a mobile to control a mobile specific classifier table present in the Home Agent memory. Each Flow Identification extension defines one filter rule line in that classifier, the output of which is one or more BIDs pointing to one or more of the registered CoAs.

Each filter rule in the classifier table can be referenced by the FID of the Flow Identification extension that created it. If the mobile wants to change the priority of a filter rule it can send a Flow Identification extension including the FID of the filter rule and setting the Priority field to the new value (or 255 for deregistration), and without including the Filter Rule Definition or any BIDs.

Filter rules do not need to be refreshed explicitly. A filter rule is valid as long as it points to a valid BID, i.e., a registered CoA. If a filter rule does not point to any valid BIDs it will be removed.

Any filter rule in the classifier table can be replaced by a new filter rule by sending a Flow Identification extension with the FID field set to the FID of the filter rule to be replaced and the rest of the extension defining the new filter rule, priority and the BIDs it points to.

Each Flow Identification extension is ranked according to its priority field. The lower the value of the priority field the higher its priority (i.e., it is checked earlier against each packet). As in most classifiers, filter rules with the same priority SHOULD be non-overlapping, otherwise the result is undefined. Overlapping filter rules SHOULD have different priorities.

Mobiles SHOULD define a default filter rule for traffic that does not match any other rule. The default filter rule MAY be defined with a Filter Identification extension with a high priority value (so it is checked last) and with the Filter Descriptor with all the flags set to 0 and the action field set to an appropriate value (e.g., forward). Note that such a Filter Descriptor will match all packets.

A mobile node can use the Flow Identification extension to associate a given flow with one or more of the registered CoAs. The mobile MUST register its CoAs with the Alternate-CoA extension in order to associate flows with them, using the BID as a handle. One or more

Flow Identification extensions and one or more Alternate-CoA extensions MAY be present in the same message.

If a Flow Identification extension includes a BID field set to the value 155 then the filter rule points to all the registered CoAs. The order of the CoAs for such a filter rule is dictated by the priority level of each BID, taken by the Priority field of the Alternate-CoA used to register them. If one or more BIDs are present in the Flow Identification extension then the filter rule points to the specific BIDs included in the extension. Note that the list of BIDs in the Flow Identification extension is ordered and its significance depends on the action indicated by the action field in the same extension.

5.2. Home Agent Considerations

5.2.1. Handling Alternate-CoA extensions

A Home Agent that supports this specification SHOULD ignore the "S" flag (Simultaneous Bindings) in the Registration Request message header when the same message includes Alternate-CoA extensions. In other words, the mechanisms defined in this specification override the mechanism defined by the "S" flag in [RFC5944].

If an Alternate-CoA extension is received by an HA in a Registration Request message, the HA SHOULD include a corresponding Alternate-CoA extension in the registration reply message. The BID of Alternate-CoA extension MUST be copied from the BID of the Alternate-CoA extension in the corresponding Registration Request and the Status field SHOULD be set to an appropriate value (e.g., indicating accept, reject etc).

When a valid Registration Request message includes one or more accepted Alternate-CoA extensions the HA MUST include the accepted CoAs in the mobility bindings table which binds the registered home address(es) with the registered CoAs together with their BIDs, priorities and lifetimes. The BID and priority of a CoA is indicated in the Alternate-CoA extension, while the lifetime is inherited from the lifetime of the registration reply message that accepted them as registered CoAs. Thus, different Alternate-CoAs will have different lifetimes if they are registered with different registration request messages, but they will have the same lifetime if they are included in the same Registration Request.

The CoAs are ranked according to their priority; the lowest the value of the priority field the higher their ranking. If an Alternate-CoA is rejected then the HA MUST NOT include it in the mobility bindings table. If the lifetime of an Alternate-CoA expires, the

corresponding CoA MUST be removed from the mobility bindings table.

If an Alternate-CoA extension is received with a BID that matches an existing BID then:

The HA MUST check the priority field of the extension in quesiton. If the priority field is set to 255 (indicating deregistration) the CoA MUST be removed from the mobility bindings table and from any filter rules that point to it.

If the priority is set to any other value, the HA MUST check the CoA field of the same extension. If the CoA field is not included, the priority of the CoA, identified by the BID included in the extension, MUST be updated with the indicated value.

If the CoA field exists and matches the CoA that the BID field points to in the HA mobility bindings table, the priority of that CoA is again updated.

If the CoA field exists and is different from the CoA the BID field points to in the HA mobility bindins table, the HA SHOULD update its table with the new CoA and priority for that BID.

If an Alternate-CoA extension is received with a BID that does not match an existing BID then:

The HA MUST check the CoA field of the extension. If the CoA field is not included, the HA SHOULD include an Alternate-CoA extension in the registration reply with a BID copied from the corresponding extension in the request message and the Status field set to "Unknown BID."

If the CoA field exists, the HA MUST store the BID, CoA and priority values in the mobility bindings table for the mobile. The CoA MUST be ranked with the other registered CoAs according to the value of the priority field.

If the CoA field exists but it matches a CoA that is already registered with a different BID the HA MAY replace the old BID with the new BID and indicate a "BID changed" in the Status field of the corresponding Alternate-CoA extension included in the registration reply message.

5.2.2. Handling Flow Identification Extensions

If a Flow Identification extension is received by an HA in a Registration Request message, the HA SHOULD include a corresponding Flow Identification extension in the registration reply message. The

FID of the Flow Identification extension in the reply message MUST be copied from the FID of the Flow Identification extension in the corresponding Registration Request and the Status field SHOULD be set to an appropriate value (e.g., indicating accept, reject etc).

When a valid Registration Request message includes one or more accepted Filter Identification extensions the HA MUST include the accepted filter rules in the mobile specific classifier table which associates the order list of filter rules with the BIDs they point to. The priority of a filter rule, the description of the filter rule, the action and the BID(s) the filter rule is associated with are indicated in the Flow Identification extension.

The filter rules are ranked according to their priority. Filter rules MUST be ranked from lowest to higher priority. If a filter rule is rejected then it MUST NOT included in the mobile specific classifier.

Each filter rules in the mobile specific classifier is valid as long as points to a valid BID, i.e., a registered CoA. If a filter rule does not point to any valid BIDs the HA MUST remove it from the mobile specific classifier.

If the HA receives a Flow Identification extension, it SHOULD first check the FID field of that extension.

If the value of the FID field does not match any of the FIDs in the mobile specific classifier, the HA SHOULD include the filter rule described in the extension in the mobile specific classifier table. The new filter rule MUST be ranked according to the priority field indicated in the Flow Identification extension.

If a one or more BIDs are included then the filter rule MUST point to the list of BIDs in the order they appear.

If any of the including BIDs do not match one of the registered BIDs in the mobile bindings table for this mobile the HA MUST disregard the Flow Identification extension and MUST return a reply message with a Flow Identification extension that includes the FID of the corresponding extension in the request message and the Status field set to an appropriate value e.g., "Unknown BID."

If a BID of value 255 is included, the filter rule MUST point to the default list of BIDs. This is the list of BIDs in the mobility bindings table for this mobile.

If a BID of value 0 is included the HA MUST disregard the Flow Identification extension and MUST return a reply message with a Flow Identification extension that includes the FID of the corresponding extension in the request message and the Status field set to an appropriate value e.g., "Unknown BID."

If the value of the FID field matches any of the FIDs in the mobile specific classifier the HA SHOULD then check the priority field of the Flow Identification extension. If the priority field is set to 255 then the filter rule associated with the FID in the Flow Identification extensions MUST be removed from the mobile specific classifier table.

If the priority field, however, is set to a value other than 255 the HA SHOULD check the Filter Description field of the Flow Identification extension.

If the Filter Description is not included (F-Type field set to 0) and the BID field is set to 0, the HA MUST adjust the ranking of the filter rule corresponding to the FID according to the priority field in the Flow Identification extension.

If any BIDs are also included in the Flow Identification extensions then the list of BIDs associated with that filter rule MUST also be replaced by the list provided in the Flow Identification extension. If a BID field set to 255 is included then the filter rules MUST be re-pointed to the default list of BIDs registered with Alternate-CoA extensions.

Note a BID field set to 0 is included the BIDs list for this filter rule in the mobility specific classifier table MUST NOT be changed.

If the priority field, however, is set to a value other than 255 and the Filter Description field is included then the HA MUST replace the corresponding filter rule in the mobile specific classifier table with the filter rule in the Flow Identification extension.

If any BIDs are also included in the Flow Identification extensions then the list of BIDs associated with that filter rule MUST also be replaced by the list provided in the Flow Identification extension. If a BID field set to 255 is included then the filter rules MUST be re-pointed to the

default list of BIDs registered with Alternate-CoA extensions.

Note that if a BID field set to 0 is included the BIDs field, the list of BIDs this filter rule points to MUST NOT be changed from its previous configuration.

6. Routing Considerations

This document allows the mobility entities to optionally exchange flow policies. In the absence of negotiated traffic flow policies, this document recommends the use of per-flow load balancing.

Most IP devices support the two alternative traffic load-balancing schemes, Per-flow and Per-packet load balancing. These load balancing schemes allow the forwarding device to evenly distribute traffic based on the criteria of per-packet or on a per-flow basis, across all the available equal-cost links through which a destination can be reached. The default forwarding behavior of Per-flow load balancing will ensure a given flow always takes the same path and will eliminate any packet re-ordering issues and that is critical for delay sensitive traffic. Whereas the per-destination load balancing scheme leverages all the paths much more affectively, but with the potential issue of packet re-ordering on the receiver end. A host can choose to enable any of these approaches.

7. Protocol Configuration Variables

The following protocol configuration variables are required for system management and these variables MUST be configurable on all the mobility entities. The configured values for these protocol variables MUST survive service restarts.

EnableMultipleTunnelSupport.

This flag indicates whether or not the mobility entity on which this protocol variable is configured needs to enable Multiple Tunnel support feature. This protocol variable is applicable to home agent, foreign agent and the mobile node.

The default value for this flag is set to value of 1, indicating that the multiple tunnel support SHOULD be enabled.

When the value for this flag is set to value of 0, multiple tunnel support SHOULD be disabled.

8. IANA Considerations

This document proposes two new extensions that require a type number to be assigned by IANA.

Section 4.1 defines a new Mobile IP extension, the Alternate-CoA Extension. Its a skippable extension to the Mobile IPv4 header in accordance to the short extension format of [RFC5944]. The type number for this extension needs to be assigned by IANA.

Section 4.2 defines a new Mobile IP extension, the Flow Identification Extension. Its a skippable extension to the Mobile IPv4 header in accordance to the short extension format of [RFC5944]. The type number for this extension needs to be assigned by IANA.

9. Security Considerations

This specification allows a mobile node to establish multiple tunnels with the home agent, by registering a care-of address for each of its active roaming interfaces. This essentially allows the mobile node's home address to be reachable through all of its active and registered roaming interfaces. This specification also allows the mobile node to bind traffic flows to the registered care-of addresses. This new capability has no impact on the protocol security.

The Mobile IP message extensions, defined in this document are to be carried in Mobile IP Registration messages and these messages are authenticated and integrity protected as described in [RFC5944].

Therefore, this specification does not weaken the security of Mobile IP Protocol, or, introduce any new vulnerabilities.

10. Contributors

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