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Flow Bindings Initiated by Home Agents for Mobile IPv6

Abstract

There are scenarios in which the home agent needs to trigger flow binding operations towards the mobile node, such as moving a flow from one access network to another based on network resource availability. In order for the home agent to be able to initiate interactions for flow bindings with the mobile node, this document defines new signaling messages and sub-options for Mobile IPv6. Flow bindings initiated by a home agent are supported for mobile nodes enabled by both IPv4 and IPv6.

Status of This Memo

This document is not an Internet Standards Track specification; it is published for examination, experimental implementation, and evaluation.

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Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at http://www.rfc-editor.org/info/rfc7109.

Table of Contents

1. Introduction

[RFC6089] allows a mobile node (MN) to bind a particular flow to a care-of address (CoA) without affecting other flows using the same home address. BU/BA (Binding Update / Binding Acknowledgement) messages are extended for the mobile node to add, delete, modify, move, refresh, and revoke flow bindings in a home agent (HA). The operations are always initiated by the mobile node.

While the mobile node manipulates flow bindings by, e.g., the user interaction or the change of the attached link condition, these operations are also required for network-related reasons such as dynamic QoS control in the network, load balancing, or maintenance in mobility agent nodes. For the latter case, the mobile node is not very aware of the transport network condition away from it or of the policy and charging status controlled by the operator; thus, the network needs to request that the mobile node handle proper flow bindings.

This document defines a new Mobility Header and messages in order for the home agent to request that the mobile node initiate flow bindings in a timely manner. Flow mobility is also supported for mobile nodes with an IPv4 home address and an IPv4 address of the home agent, as described in [RFC5555].

2. Terminology

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

The terminology in this document is based on the definitions in [RFC6275] and [RFC6089].

3. Use Cases

3.1. QoS Provisioning

When the user launches a video chat application and starts sending voice and video to the other end, the network may need to provide different QoS treatments to these media based on the operator’s policy. In such a case, the network needs to request the user or mobile node to establish separate flows for voice and video.

3.2. Traffic Offload from Congested Network

The 3G operator may want to move traffic flows from the 3G access network to another network (e.g., Wi-Fi network) due to instantaneous traffic increases in the 3G access network. Fine-grained traffic offload is desirable. For example, Voice over IP (VoIP) flows based on IP Multimedia Subsystems (IMS) must stay in the mobile core network while video-streaming flows provided by servers on the Internet could bypass the mobile core network via Wi-Fi access. Since the network knows more about its conditions and has access to the policy server, more timely and well-controlled traffic offloading is possible. The home agent sends an updated flow descriptor to be offloaded to the mobile node.

3.3. Flow Movement or Deletion in an Emergency Situation

In an emergency situation caused by a natural disaster, it is necessary to accept as many voice calls as possible for inquiries to confirm the safety status of family and friends, while non-critical services such as gaming would be considered lower priority. In order to save the 3G / Long Term Evolution (LTE) radio resources for emergency services, non-critical services may need to be moved to another access network or closed down. The home agent requests that the mobile node use Wi-Fi access for non-critical application flows or terminate them gracefully, e.g., by letting it notify the user of possible QoS degradation or ask him/her to finish the corresponding applications before taking any action.

3.4. Service-Specific Data Cap

The mobile operator offers a mobile broadband service with a flat rate subscription limited to 5 GB per month. Once the allotment is used up, the service is downgraded to 64 kbits/s. This limitation, however, is not applied to IMS-based services (e.g., Voice over LTE (VoLTE)), while video conversations over the Internet will be affected. The operator can indicate this to the user by sending modified flow descriptors as a proposal to adjust the communication data rate or change access for an ongoing session.

4. Protocol Operation

[RFC6089] makes use of BU/BA signaling to forward, i.e., register or discard, a flow binding in a home agent. Flow binding operations are always initiated from the mobile node. The basic principle of this specification is that the home agent prompts the mobile node to perform flow binding operations. For this purpose, a new Mobility Header and two new messages, that is, Flow Binding Indication (FBI) and Flow Binding Acknowledgement (FBA), are defined. An FBI is used

by the home agent to request flow binding operations to the mobile node, and an FBA is used for acknowledging an FBI. In order for the flow binding operation to be complete, a BU/BA exchange MUST be initiated by the mobile node after an FBI/FBA exchange.

It is assumed that the home agent has already created binding cache entries for the mobile node before launching flow binding operations.

Due to access-network change on the mobile-node side, some interfaces that used to be active may not be valid at the time of the flow binding operation by the home agent, in which case, even if the HA sends the FBI to the MN, the FBA will not return. After retransmitting the FBIs for MAX_FBI_RETRIES times and not receiving the FBA, the HA determines that the target interface is not available.

If the mobile node does not support the FBI message, it responds with a Binding Error message with status set to 2 (unrecognized Mobility Header (MH) type value) as described in [RFC6275]. When the Binding Error message with status set to 2 is received in response to an FBI message, the home agent MUST NOT use an FBI message with that mobile node again.

4.1. Adding Flow Bindings

Adding the flow binding implies associating a particular flow with one of the care-of addresses on the mobile node. The care-of address concerned with the flow binding is present in the destination address of the packet or the alternate care-of address option. Alternatively, the care-of address may be indicated by the Target Care-of Address sub-option defined in Section 6.2.2.

When adding a new flow binding, the home agent sends an FBI with a Flow Identification Mobility option to the mobile node. In Figure 1, which is shown as an example for this operation, the mobile node exchanges both voice and video over FID#1 (Flow Identifier #1). Based on the operator’s policy, the network determines if it needs to provide separate QoS for the video flow, and the home agent sends the FBI to the mobile node. The Flow Identification Mobility option defined in [RFC6089] includes the current FID and the Traffic Selector (TS) to specify the video flow. The Flow Binding Action sub-option MUST indicate the Add operation defined in Section 6.2.1. The mobile node returns the FBA to the home agent with the same options. The BU/BA exchange follows afterwards to perform the actual flow binding as defined in [RFC6088], and the video traffic is exchanged over FID#2.

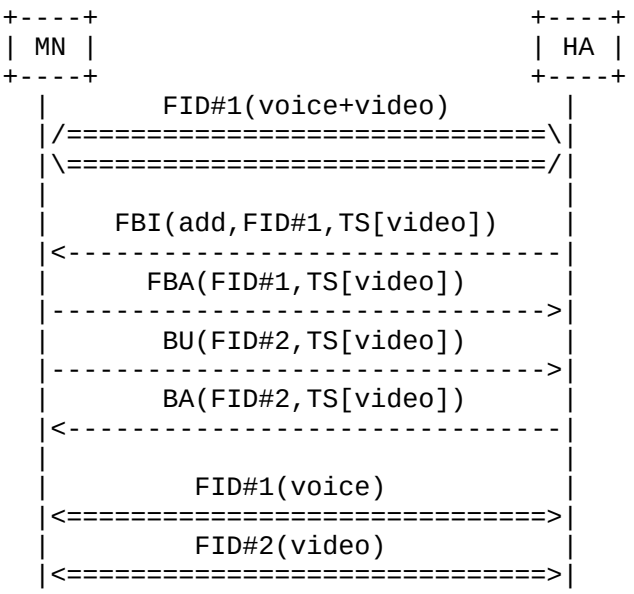

Figure 1: Example Call Flow for Adding a Flow Binding

4.2. Deleting Flow Bindings

When removing a flow binding, the home agent sends an FBI with a Flow Identification Mobility option in which the Flow Binding Action sub-option indicates the Delete operation. The Flow Identification Mobility option includes a unique FID for the mobile node to locate the flow binding and remove it.

4.3. Modifying Flow Bindings

When modifying a flow binding (e.g., changing QoS attributes of the flow as defined in [PMIP6-QOS]) is needed, the home agent sends the mobile node an FBI message with the Flow Identification Mobility option. The option includes the FID to be modified. A Traffic Selector sub-option MAY come with the Flow Identification Mobility option and contain new attributes, e.g., the in Quality of Service option.

4.4. Refreshing Flow Bindings

A flow binding is refreshed by simply including the Flow Identification Mobility option with the Refresh Action field in the FBI message. The message should be sent before the expiration of the flow binding. The message updates existing bindings with new

information. Hence, all information previously sent in the last refreshing message need to be resent; otherwise, such information will be lost.

4.5. Moving Flow Bindings

The home agent can request to move a flow associated with one interface of the multi-interfaced mobile node to another by sending an FBI message to the mobile node. The Action field of the Flow Binding Action sub-option is set to Move, and the address of the target interface is also included in the Target Care-of Address sub-option. After the FBA is returned to the home agent, the flow mobility is performed by the mobile node. Figure 2 shows the movement of a flow label as FID from the interface with sCoA to that with tCoA, which is stored in the Binding Identity Mobility option.

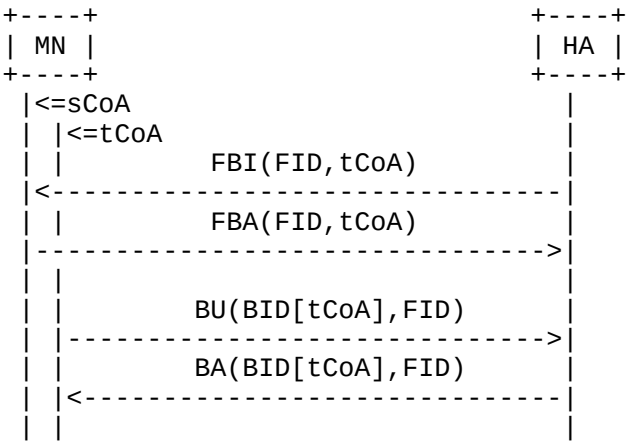

Figure 2: Example Call Flow for Moving a Flow Binding

4.6. Revoking Flow Bindings

When the home agent or the network attached to it is overloaded, the home agent can revoke a flow binding registered by the mobile node. The home agent sends the mobile node an FBI message with a Flow Identification Mobility option in which the Flow Binding Action sub-option indicates the Revoke operation. When the MN receives the FBI message with the Revoke operation, it decides whether the flow should be removed (de-registration) or moved to another interface and returns the FBA with an appropriate status code. The mobile node SHOULD take an action by sending a new BU, for example, to deregister the flow.

The difference between revoking and deleting flow bindings (Section 4.2) is that the target flow may be revoked by the network with the procedures defined in [RFC5846] even if the mobile node does not take any action.

5. Handling of the Flow Bindings List

The flow bindings list defined in [RFC6089] needs to be updated as follows after each protocol operation defined above is performed:

If an FBI contains a flow binding Add operation and if the corresponding FBA has a status code equal to zero, the home agent MUST add a new entry to the flow bindings list. The FID, Flow Descriptor, FID-PRI, and Action fields are taken from the Flow Identification Mobility option. The binding identifier (BID) is copied from the Binding Reference sub-option. The Active/Inactive Flag is set to Active. Note that if BID is not available, it may be replaced by Target Care-of Address.

If an FBI contains a flow binding Delete operation and if the corresponding FBA has a status code equal to zero, the home agent MUST locate the list entry corresponding to this flow and then delete the entry.

If the home agent sends a Binding Revocation Indication message with the Flow Identification Mobility option with the action field set to Revoke and if the corresponding Binding Revocation Acknowledgement message indicates acceptance, the home agent MUST locate the list entry corresponding to this flow and then delete the entry.

If an FBI contains a flow binding Modify operation and if the corresponding FBA has a status code equal to zero, the home agent MUST delete the list entry corresponding to this flow and then add a new entry, setting the values as defined in the Flow Identification Mobility option.

If an FBI contains a flow binding Refresh operation and if the corresponding FBA has a status code equal to zero, the home agent MUST locate the list entry corresponding to this flow and then set the Active/Inactive Flag to Active.

If an FBI contains a flow binding Move operation and if the corresponding FBA has a status code equal to zero, the home agent MUST locate the list entry corresponding to this flow and then change the BID value to the care-of address in the Flow Identification Mobility option.

If an FBI contains a flow binding Revoke operation and if the corresponding FBA has a status code equal to zero, the home agent MUST locate the list entry corresponding to this flow and then delete the entry.

Flow binding operations apply equally to IPv4 packets and IPv6 packets as per Dual-Stack Mobile IPv6 [RFC5555]. In order to support the situation where there is a NAT/firewall between the mobile node and home agent, NAT detection and NAT keepalive mechanisms defined in [RFC5555] MUST be used. When the mobile node and home agent are in IPv6-only and IPv4-only networks respectively and NAT64 [RFC6146] resides in between, each node would behave as if the other node was in the same network domain. Even though this scenario is not fully described in [RFC5555], the initial mobility binding is always performed by the mobile node, and the binding cache is created in the home agent. The destination address of the FBI SHALL be the mobile node's IPv4 care-of address in the binding cache entry.

6. Flow Binding Messages and Options

6.1. Mobility Header

The messages described below follow the Mobility Header format specified in Section 6.1 of [RFC6275].

6.1.1. Flow Binding Indication

Flow Binding Indication messages are used by the home agent to initiate flow binding operations to the mobile node. Flow Binding Indication messages use the MH Type value (21) for Flow Binding messages and a Flow Binding Type value of 1, and the format of the Message Data field in the Mobility Header is as follows:

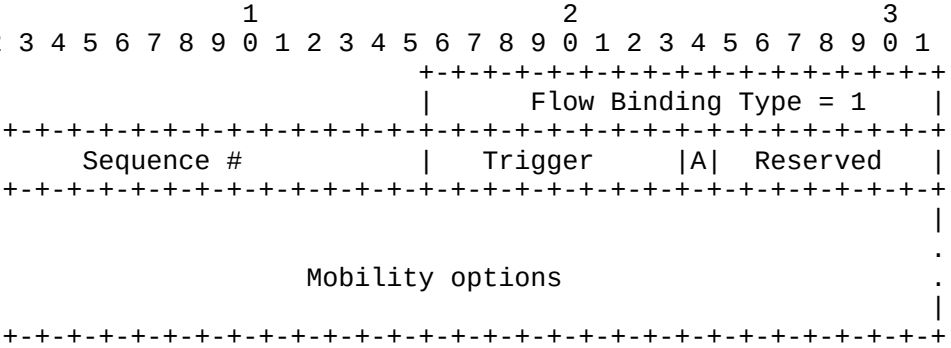

Figure 3: Flow Binding Indication Mobility Header Format

Sequence #
A 16-bit unsigned integer used by the home agent to match a returned Flow Binding Acknowledgement with the Flow Binding Indication. It could be a random number.

Trigger
8-bit unsigned integer indicating the event that triggered the home agent to send the Flow Binding Indication message. The following Trigger values are currently defined:

0 Reserved

1 Unspecified

2 Administrative Reason

3 Possible Out-of-Sync BCE State

250-255 Reserved for Testing Purposes Only

All other values are unassigned.

Acknowledge (A)
The Acknowledge (A) bit is set by the home agent to request that a Flow Binding Acknowledgement be returned upon receipt of the Flow Binding Indication.

Reserved
These fields are unused. They MUST be initialized to zero by the sender and MUST be ignored by the receiver.

Mobility options
Variable-length field of such length that the complete Mobility Header is an integer multiple of 8 octets long. Flow Identification Mobility options are included in this field.

6.1.2. Flow Binding Acknowledgement

The Flow Binding Acknowledgement is used to acknowledge receipt of a Flow Binding Indication. The mobile node sends an FBA message to acknowledge the reception of an FBI to add, delete, modify, refresh, move, or revoke a flow binding. On receiving messages with Flow Identification Mobility option(s), the mobile node should copy each Flow Identification Mobility option to the Acknowledgement message. The Flow Binding Acknowledgement has the MH Type value (21) for Flow Binding messages and a Flow Binding Type value of 2. When this value is indicated in the MH Type field, the format of the Message Data field in the Mobility Header is as follows:

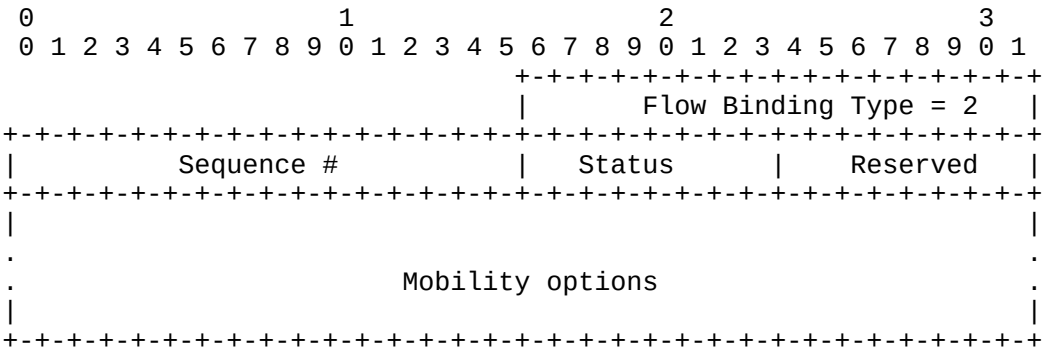

Figure 4: Flow Binding Acknowledgement Mobility Header Format

Sequence #
The sequence number in the Flow Binding Acknowledgement is copied from the Sequence Number field in the Flow Binding Indication.

Status
8-bit unsigned integer indicating the result of processing the Flow Binding Indication message by the receiving mobile node. Values less than 128 in the Status field indicate that the Flow Binding Indication was processed successfully by the receiving node. Values greater than or equal to 128 indicate that the Flow Binding Indication was rejected by the receiving node. The following status values are currently defined:

0 Success

128 Binding (target CoA) Does NOT Exist

129 Action NOT Authorized

All other values are unassigned.

Mobility options
Variable-length field of such length that the complete Mobility Header is an integer multiple of 8 octets long. This field contains zero or more TLV-encoded mobility options. Flow Identification Mobility options are included in this field.

6.1.3. Flow Binding Revocation Extensions

This specification enables Binding Revocation Indication and Binding Revocation Acknowledgement messages to carry Flow Identification Mobility options as defined in [RFC6089] with the extensions defined in this document.

6.2. New Options

This document defines new Flow Identification sub-options that are included in the Flow Identification Mobility option specified in [RFC6089].

6.2.1. Flow Binding Action Sub-Option

This section defines a new sub-option for flow binding actions, which MUST be included in the Flow Identification Mobility option when it is sent from the home agent to the mobile node via the FBI message. The format of this sub-option is shown in Figure 5.

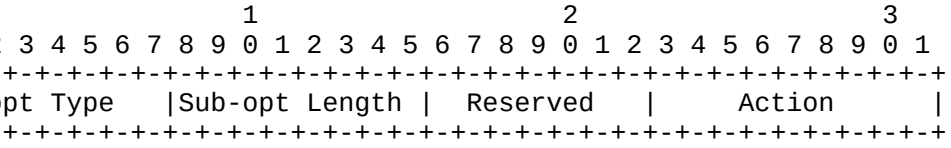

Figure 5: Flow Binding Action Sub-Option

Sub-opt Type
4

Sub-opt Length
Length of the sub-option in octets, excluding the Sub-opt Type and Sub-opt Length fields.

Action
This is a 8-bit field that describes the required processing for the option. It can be assigned one of the following new values:

11 Add a flow binding

12 Delete a flow binding

13 Modify a flow binding

14 Refresh a flow binding

15 Move a flow binding

16 Revoke a flow binding

All other values are unassigned.

6.2.2. Target Care-of Address Sub-Option

This section introduces the Target Care-of Address sub-option, which may be included in the Flow Identification Mobility option. This sub-option is used to indicate to the mobile node that a flow binding is to be moved from one interface to another.

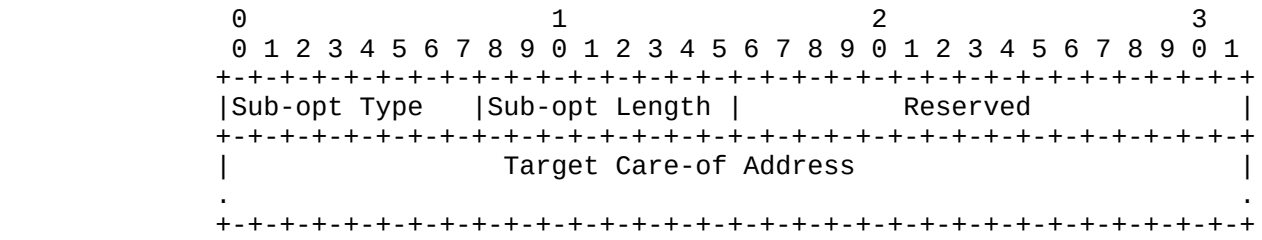

Figure 6: Target Care-of Address Sub-Option

Sub-opt Type
5

Sub-opt Length
Length of the sub-option in octets, excluding the Sub-opt Type and Sub-opt Length fields.

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

Target Care-of Address
The address of an interface that the flow is moved to. This address could be an IPv4 or IPv6 address. This sub-option MUST be included when the action taken is "15 Move a flow binding".

7. Security Considerations

Security issues for this document follow those of [RFC6088], [RFC6089], and [RFC5846]. This specification allows the home agent to manipulate only the binding of a flow(s) that is currently registered with it, which is the same principle described in [RFC5846]. No additional security issue specific to this document is identified.

8. Protocol Constants

Maximum FBI retries (MAX_FBI_RETRIES)
: This variable specifies the maximum number of times the HA MAY retransmit a Flow Binding Indication message when the FBA is not returned within the time period specified by MAX_FBA_TIMEOUT. The default value for this parameter is 3.

Maximum FBA timeout (MAX_FBA_TIMEOUT)
: This variable specifies the maximum time in seconds the HA MUST wait before retransmitting another FBI message. The default for this parameter is 3 seconds.

9. IANA Considerations

IANA has taken the actions described below.

Action-1
: This specification defines a new Mobility Header Type, "Flow Binding Message". This Mobility Header message is described in Section 6.1, and the type value for this messages is 21, which has been assigned in the "Mobility Header Types - for the MH Type field in the Mobility Header" registry.

Action-2
: This specification defines "Flow Binding Type". IANA has created a new sub-registry within the "Mobile IPv6 parameters" registry. Flow Binding Type is described in Sections 6.1.1 and 6.1.2, which reserve the following values:

Value	Description	Reference
0	Unassigned	
1	Flow Binding Indication	[RFC7109]
2	Flow Binding Acknowledgement	[RFC7109]
3-255	Unassigned	

Future assignments in the "Flow Binding Type" registry are to be made through RFC Required [RFC5226].

Action-3

This specification defines "Flow Binding Indication Triggers". IANA has created a new sub-registry within the "Mobile IPv6 parameters" registry. The trigger values are described in Section 6.1.1, which reserves the following values:

Value	Description	Reference
0	Reserved	[RFC7109]
1	Unspecified	[RFC7109]
2	Administrative Reason	[RFC7109]
3	Possible Out-of-Sync BCE State	[RFC7109]
4-249	Unassigned	
250-255	Reserved for Testing Purposes Only	[RFC7109]

Future assignments in the "Flow Binding Indication Triggers" registry are to be made through RFC Required [RFC5226].

Action-4

This specification defines "Flow Binding Acknowledgement Status Codes". IANA has created a new sub-registry within the "Mobile IPv6 parameters" registry. The status codes are described in Section 6.1.2, which reserves the following values:

Value	Description	Reference
0	Success	[RFC7109]
1-127	Unassigned	
128	Binding (target CoA) Does NOT Exist	[RFC7109]
129	Action NOT Authorized	[RFC7109]
130-255	Unassigned	

Future assignments in the "Flow Binding Acknowledgement Status Codes" are to be made through RFC Required [RFC5226].

Action-5

This specification defines two new Flow Identification sub-options: the "Flow Binding Action" sub-option and "Target Care-of Address" sub-option. These sub-options are described in Sections 6.2.1 and 6.2.2, and the sub-option values are 4 and 5, respectively, as assigned in the "Flow Identification Sub-options" registry.

Action-6

This specification defines "Flow Binding Action Values". IANA has created a new sub-registry within the "Mobile IPv6 parameters" registry. The action values are described in Section 6.2.1, which reserves the following values:

Value	Description	Reference
0-10	Unassigned	
11	Add a flow binding	[RFC7109]
12	Delete a flow binding	[RFC7109]
13	Modify a flow binding	[RFC7109]
14	Refresh a flow binding	[RFC7109]
15	Move a flow binding	[RFC7109]
16	Revoke a flow binding	[RFC7109]
17-255	Unassigned	

Future assignments in the "Flow Binding Action Values" registry are to be made through RFC Required [RFC5226].

10. References

10.1. Normative References

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[RFC5846] Muhanna, A., Khalil, M., Gundavelli, S., Chowdhury, K., and P. Yegani, "Binding Revocation for IPv6 Mobility", RFC 5846, June 2010.

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10.2. Informative References

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