Network Working Group   A. Muhanna
Internet-Draft   M. Khalil
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Expires: April 3, 2010   S. Gundavelli
                                                       Cisco Systems
                                                        K. Chowdhury
                                                    Starent Networks
                                                           P. Yegani
                                                    Juniper Networks
                                                  September 30, 2009

                    Binding Revocation for IPv6 Mobility
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Abstract

   This document defines a binding revocation mechanism to terminate a
   mobile node's mobility session and the associated resources. These
   semantics are generic enough and can be used by mobility entities in
   the case of Mobile IPv6 and its extensions. This mechanism allows
   the mobility entity which initiates the revocation procedure to
   request its peer to terminate either one, multiple or all specified
   binding(s).

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1. Introduction

   In the case of Mobile IPv6 and for administrative reason, sometimes
   it becomes necessary to inform the mobile node that its registration
   has been revoked and the mobile node is no longer able to receive IP
   mobility service using its Home Address. A similar Mobile IPv4
   registration revocation mechanism [RFC3543] has been specified by
   IETF for providing a revocation mechanism for sessions that were
   established using Mobile IPv4 registration [RFC3344].

   This document specifies a binding revocation mechanism that can be
   used to revoke a mobile node's mobility session(s). The same
   mechanism can be used to revoke bindings created using Mobile IPv6
   [RFC3775] or any of its extensions, e.g. Proxy Mobile IPv6
   [RFC5213]. The proposed revocation mechanism uses a new Mobility
   Header (MH) type <IANA-TBD> for revocation signaling which is
   applicable to Mobile IPv6 [RFC3775] and Proxy Mobile IPv6 [RFC5213]
   and can be used by any two IP mobility entities. As an example, this
   mechanism allows a local mobility anchor (LMA), involved in providing
   IP mobility services to a mobile node, to notify the mobile access
   gateway (MAG) of the termination of that mobile node binding
   registration. In another example, a mobile access gateway can use
   this mechanism to notify its local mobility anchor peer with a bulk
   termination of all or a subset of proxy mobile IPv6 (PMIPv6) bindings
   that are registered with the local mobility anchor and currently
   being served by the mobile access gateway. Any mobility entity is
   allowed to revoke only the registration of those mobile node(s)
   mobility sessions that are currently registered with it.

2. Conventions & Terminology

2.1. Conventions used in this document

   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].

2.2. Terminology

   All the general mobility related terminology and abbreviations are to
   be interpreted as defined in Mobile IPv6 [RFC3775] and Proxy Mobile
   IPv6 [RFC5213] specifications. The following terms are used in this
   specification.

   Initiator

      The mobility node that initiates the binding revocation procedure
      by sending a Binding Revocation Indication message to its peer,
      e.g., home agent, local mobility anchor, or mobile access gateway.

   Responder

      The mobility node that receives the Binding Revocation Indication
      message and responds with a Binding Revocation Acknowledgement
      message. e.g., mobile node, mobile access gateway, or local
      mobility anchor.

3. Binding Revocation Protocol and Use Cases Overview

   This specification specifies a generic binding revocation mechanism
   where a mobility node can communicate to the mobile node or another
   mobility node the identity of the the mobile node registration
   binding that is being terminated. In the case when this mechanism is
   used for bulk termination or multiple bindings, the identities of
   these bindings are communicated to the mobile node or mobility node
   using the same generic mechanism. The following subsections present
   the protocol overview and applicable use cases.

3.1. Binding Revocation Protocol

   In the case of Mobile IPv6, if the home network decides to terminate
   the service of the mobile node, the home agent sends a Binding
   Revocation Indication (BRI) message to the mobile node. The home
   agent includes the home address (HoA) of the mobile node in the Type
   2 routing header as specified in [RFC3775] to indicate the impacted
   mobile node binding. In the case of Dual Stack Mobile IPv6 (DSMIPv6)
   [RFC5555], the home agent may include the IPv4 Home Address option
   with the mobile node assigned home IPv4 address. Additionally, if
   the mobile node registered multiple care-of addresses [ID-MCoA], the
   home agent includes the Binding Identifier (BID) option(s) in the
   Binding Revocation Indication message to identify which binding is
   being revoked. When the mobile node receives a Binding Revocation
   Indication message with its HoA included in the Type 2 routing
   header, the mobile node responds by sending a Binding Revocation
   Acknowledgement (BRA) message.

   Similarly, in the case of Proxy Mobile IPv6 [RFC5213], the revocation
   procedure can be initiated by the local mobility anchor by sending a
   Binding Revocation Indication message to communicate the termination
   of a mobile node registration binding to the mobile access gateway.
   In this case, the local mobility anchor includes the mobile node Home

Network Prefix (MN-HNP) option [RFC5213] and the MN-ID option
[RFC4283] to indicate to the mobility access gateway the identity of
the PMIPv6 binding that needs to be terminated. When the mobile
access gateway receives the Binding Revocation Indication message,
the mobile access gateway responds to the local mobility anchor by
sending a Binding Revocation Acknowledgement message.

On the other hand, the mobile access gateway usually sends a de-
registration message by sending a Proxy Binding Update with a
lifetime of zero to indicate to the local mobility anchor of the
termination of the PMIPv6 mobile node binding registration. In this
case, the mobile access gateway includes the MN-HNP option, the MN-ID
option and all other required mobility options as per [RFC5213] in
order for the local mobility anchor to identify the mobile node
PMIPv6 binding. Additionally, in the case when the mobile access
gateway communicates a bulk termination of PMIPv6 mobility sessions,
the mobile access gateway sends a Binding Revocation Indication
message with the Global (G) bit is set and includes the mobile access
gateway identity in the MN-ID option, see Section 9.2 and
Section 8.2. When the local mobility anchor receives such Binding
Revocation Indication message, it ensures that the mobile access
gateway is authorized to send such bulk termination message, see
Section 13, and then processes the Binding Revocation Indication
message accordingly. If the local mobility anchor processes the
Binding Revocation Indication message successfully, the local
mobility anchor responds to the mobile access gateway by sending
Binding Revocation Acknowledgement message.

In any of the above cases, the initiator of the binding revocation
procedure, e.g., home agent, local mobility anchor, or mobile access
gateway, uses the Revocation Trigger field in the Binding Revocation
Indication message to indicate to the receiving node the reason for
initiating the revocation procedure.

3.2. MIPv6 and DSMIP6 Use Case

The binding revocation mechanism is applicable to Mobile IPv6 and
DSMIPv6 session(s) when the home agent needs to inform the mobile
node that its binding registration has been revoked, e.g. for an
administrative reason. This mechanism enables the user or the mobile
node to react to the revocation, e.g., reinstate its interrupted
Mobile IPv6 services.

In this case, the home agent sends a Binding Revocation Indication
message to indicate to the mobile node that its current mobile IPv6
(MIPv6) binding has been revoked and it is no longer able to receive
IP mobility service. The home agent includes the HoA in Type 2
routing header as used in [RFC3775] and sets the Revocation Trigger

field to a proper value, e.g., Administrative Reason. In the case of
DSMIPv6 session, the home agent may additionally include the mobile
node assigned IPv4 Home Address in the IPv4 Home Address option.
When the mobile node receives the Binding Revocation Indication
message, it sends a Binding Revocation Acknowledgement message to the
home agent. Figure 1 illustrates the message sequencing when home
agent revokes a mobile node binding registration.

```
   MN                                                   HA
    |                                                    |
    |            HoA in Type 2 Hdr                       |
    |<<<------------...   +   ...-----------------|
    |        BRI [seq.#, Revocation Trigger]       |
    |                                                    |
    |                                                    |
    |  BRA (HoA in Dest. Option)[seq.#, Status]   |
    |--------------------------------------->>>|
    |                                                    |
    |                                                    |
```
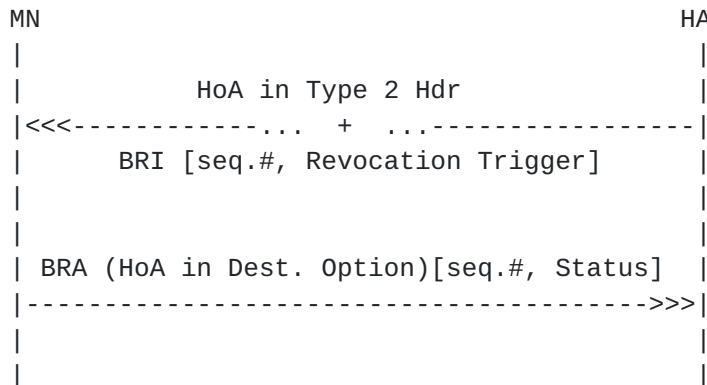
       Figure 1: Home Agent Revokes a Mobile Node Binding Registration

3.3. Multiple Care-of Addresses (Monami6) Use Case

   In the case of multiple care-of addresses registration [ID-MCoA], the
   home agent maintains different binding for each pair of care-of
   address and home address. These bindings are also indexed and
   identified during the mobile node registration using a BID mobility
   option. The HA may revoke one or multiple bindings for the same
   mobile node home address.

   If the home agent revokes a single binding for a mobile node with
   multiple care-of addresses registration, the home agent sends a
   Binding Revocation Indication message to the mobile node with the
   corresponding BID option included. If more than one of the mobile
   node registered care-of addresses need to be revoked, the home agent
   includes all the corresponding BID options in the same Binding
   Revocation Indication message. Figure 2 illustrates the message flow
   when the home agent revokes two registered Care-of addresses for the
   same mobile node in a single Binding Revocation Indication message.

```
                                                   HA Binding Cache
                                                   ================
                                                   MN-BID1 [CoA1+HoA]
   MN                                         HA   MN-BID2 [CoA2+HoA]
    |                                          |   MN-BID3 [CoA3+HoA]
    |                                          |   MN-BID4 [CoA4+HoA]
    |              HoA in Type 2 Hdr           |
    |<<<<--------------  +  --------------------|
    |     BRI [seq.#, R. Trigger, BID1, BID4]   |
    |                                          |
    |                                          |
    | BRA (HoA in Dest. Option) [seq.#, Status] |
    |------------------------------------------->>>>|
    |                                          |
    |                                          |
```

       Figure 2: Home Agent Revokes MN's Specific Care-of Addresses Bindings
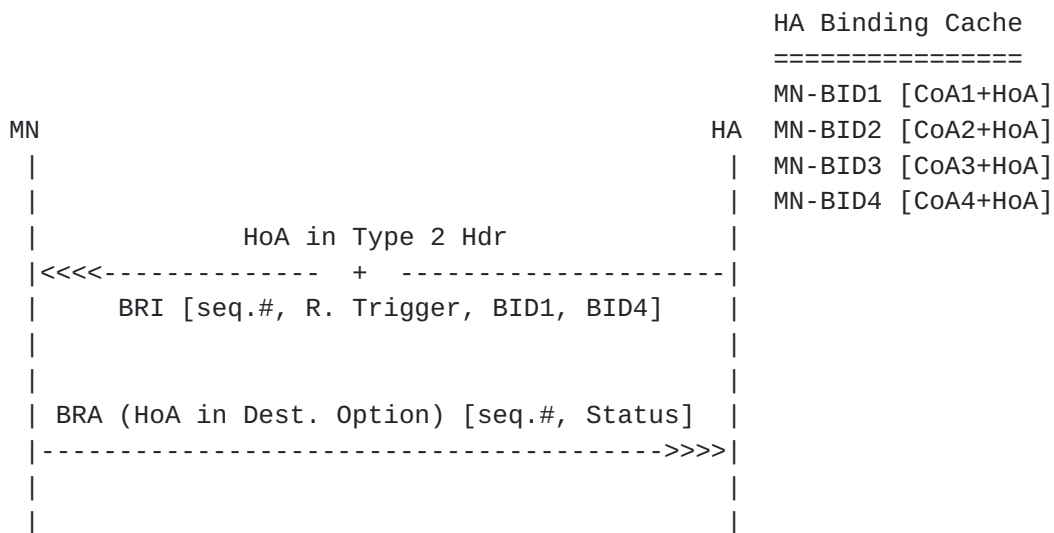

   Additionally, the home agent may revoke all of the mobile node
   registered bindings, by sending a BRI message without including any
   BID options while the HoA is included in the Type 2 routing header.
   Figure 1 illustrates the message flow when the home agent revokes all
   registered Care-of addresses bindings for a mobile node in a single
   Binding Revocation Indication message.

3.4. Proxy MIPv6 Use Case

   Since the mobile node does not participate in the mobility mechanism
   in the case of PMIPv6, there are many scenarios where the Binding
   Revocation mechanism is needed to clean resources and make sure that
   the mobility entities, i.e., mobile access gateway and local mobility
   anchor, are always synchronized with respect to the status of the
   existing PMIPv6 bindings. The binding revocation mechanism is
   generic enough that can be used for all Proxy Mobile IPv6 scenarios
   that follow [RFC5213] and [ID-PMIP6-IPv4] specifications.

   When the mobile access gateway receives a Binding Revocation
   Indication message as in Section 9.1, the mobile access gateway sends
   a Binding Revocation Acknowledgement message to the local mobility
   anchor following the rules described in Section 6.1.2. Similarly, if
   the local mobility anchor receives a Binding Revocation Indication
   message, the local mobility anchor responds to the mobile access
   gateway by sending a Binding Revocation Acknowledgement message.

3.4.1. Local Mobility Anchor Initiates PMIPv6 Revocation

   The local mobility anchor may send a Binding Revocation Indication
   message with the appropriate revocation trigger value to the mobile
   access gateway that hosts a specific PMIPv6 binding to indicate that
   the mobile node binding has been terminated and the mobile access
   gateway can clean up the applicable resources. When the mobile
   access gateway receives a Binding Revocation Indication message, the
   mobile access gateway identifies the respected binding and it sends a
   Binding Revocation Acknowledgement message to the local mobility
   anchor. In this case, the mobile access gateway could send a Router
   Advertisement message to the mobile node with the home network prefix
   valid lifetime set to zero.

   As an example, Figure 3, illustrates the message sequence for
   revoking a mobile node binding at the source mobile access gateway
   during the mobile node inter-MAG handover. During the inter-MAG
   handover, the mobile node moves from the source MAG to the target
   MAG. The target MAG sends a Proxy Binding Update with the new care-
   of-address to the local mobility anchor to update the mobile node's
   point of attachment. Since the mobile node binding at the local
   mobility anchor points to the source MAG and upon receiving the Proxy
   Binding Update from the target MAG, the local mobility anchor updates
   the MN Binding Cache Entry (BCE) and send a Proxy Binding
   Acknowledgement to the target MAG. The local mobility anchor can
   send a Binding Revocation Indication message with the appropriate
   revocation trigger value, e.g. inter-MAG handover - different Access
   Types, to the source MAG in order to clean up the applicable
   resources reserved for the specified mobile node binding. The source
   mobile access gateway acknowledges the Binding Revocation Indication
   message by sending a Binding Revocation Acknowledgement message to
   indicate the success or failure of the termination of the mobile
   node's binding.

   The process identified above can also be used by the local mobility
   anchor in scenarios other than the inter-MAG handover with the proper
   revocation trigger value to indicate to the peer mobile access
   gateway that a specific PMIPv6 binding or bindings have been revoked.

```
        oldMAG          newMAG                          LMA
          |               |                              |
          |               |            PBU               |
          |               |----------------------------->|
          |               |                       PBU triggers
          |               |                     BRI Msg to oldMAG
          |               |                              |
          |               |            PBA               |
          |               |<-----------------------------|
          |               |                              |
          |               |                              |
          |      BRI [seq.#, R. Trigger, P bit, NAI]     |
          |<--------------------------------------------|
          |               |                              |
          |               |                              |
          |               |                              |
          |               |                              |
          |          BRA [seq.#, Status, P bit]          |
          |-------------------------------------------->|
          |               |                              |
          |               |                              |
```
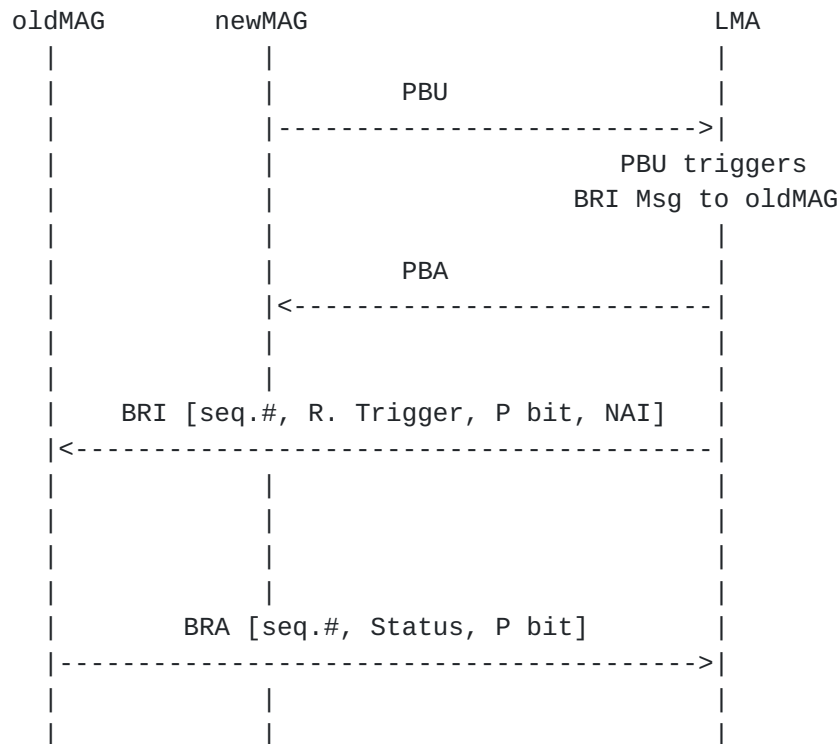
Figure 3: LMA Revokes a MN Registration During Inter-MAG Handover

In addition, the local mobility anchor can send a Binding Revocation
Indication message to indicate that all bindings which are hosted by
the peer mobile access gateway and registered with the local mobility
anchor are being revoked by setting the Global (G) bit as described
in Section 8.1.

3.4.2. Mobile Access Gateway Revokes Bulk PMIPv6 Bindings

The mobile access gateway sends a BRI message with the Global (G) bit
set and the Revocation Trigger field set to "Per-Peer Policy" to
indicate that all mobility bindings which are registered at the local
mobility anchor and attached to the mobile access gateway are being
revoked as in Section 9.2. When the local mobility anchor receives
this Binding Revocation Indication message from the specified mobile
access gateway, the local mobility anchor first checks if the mobile
access gateway is authorized to use global revocations, then it
responds with the appropriate status code by sending a Binding
Revocation Acknowledgement message as in Section 6.1.2.

4. **Binding Revocation Messages over IPv4 Transport Network**

   In some deployments, the network between the mobile access gateway
   and the local mobility anchor may only support IPv4 transport.
   Another case is when a mobile node which supports client mobile IPv6
   roams to an access network where only IPv4 addressing and transport
   is supported. In this case, the mobile node is required to register
   an IPv4 home address with its home agent using a mobile IPv6 Binding
   Update message.

   If the Proxy Binding Update and Proxy Binding Acknowledgement
   messages or the Binding Update and Binding Acknowledgement messages
   are sent using UDP encapsulation [ID-PMIP6-IPv4] and [RFC5555] to
   traverse NATs, then the Binding Revocation messages are sent using
   the same UDP encapsulation. The same UDP source and destination port
   numbers and IPv4 addresses used for exchanging the Proxy Binding
   Update and Proxy Binding Acknowledgement or the Binding Update and
   Binding Acknowledgement messages MUST be used when transporting
   Binding Revocation messages over IPv4 using UDP encapsulation. For
   example, the source UDP port number, the destination UDP port number,
   the source IPv4 address, and the destination IPv4 address of the
   Binding Revocation Indication message are set to the destination UDP
   port number, the source UDP port number, destination IPv4 address,
   and source IPv4 address of the latest received and successfully
   processed Proxy Binding Update or Binding Update message,
   respectively. For more details on tunneling Proxy Mobile IPv6 and
   Mobile IPv6 signaling messages over IPv4, see [ID-PMIP6-IPv4] and
   [RFC5555], respectively.

5. **Binding Revocation Message**

   This section defines the Binding Revocation Message format using a MH
   Type <IANA-TBD> as illustrated in Figure 4. The value in the Binding
   Revocation Type field defines whether the Binding Revocation message
   is a Binding Revocation Indication or Binding Revocation
   Acknowledgement. If the Binding Revocation type field is set to 1,
   the Binding Revocation Message is a Binding Revocation Indication as
   in Section 5.1. However, if the value is 2, it is a Binding
   Revocation Acknowledgement message as in Section 5.2.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Payload Proto |  Header Len   |    MH Type    |    Reserved   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Checksum            |   B.R. Type   |               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+               +
|                                                               |
.               Binding Revocation Message Data                 .
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
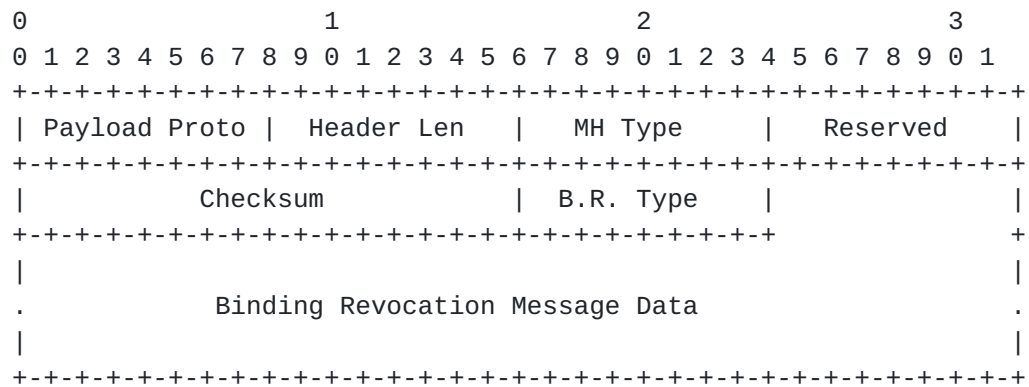
Figure 4: Binding Revocation Message

Payload Proto

   8-bit selector. see [RFC3775] for more details.

Header Len

   8-bit unsigned integer. representing the length of the Mobility
   Header in units of 8 octets, excluding the first 8 octets. see
   [RFC3775] for more details.

MH Type

   <IANA-TBD> which identifies the mobility message as a Binding
   Revocation message.

Reserved

   8-bit field reserved for future use. The value MUST be
   initialized to zero by the sender, and MUST be ignored by the
   receiver.

Checksum

   16-bit unsigned integer. This field contains the checksum of the
   Mobility Header. The checksum is calculated as described in
   [RFC3775].

Binding Revocation Type

   8-bit unsigned integer. It defines the type of the Binding
   Revocation Message. It can be assigned one of the following
   values:

             0   Reserved
             1   Binding Revocation Indication Message
             2   Binding Revocation Acknowledgement Message
             All other values are reserved

   Binding Revocation Message Data

      The Binding Revocation Message Data follows the Binding Revocation
      Message format that is defined in this document for the specified
      value in the Binding Revocation Type field. In this document, it
      is either a Binding Revocation Indication as in Section 5.1 or
      Binding Revocation Acknowledgement as in Section 5.2.

5.1. Binding Revocation Indication Message

   The Binding Revocation Indication (BRI) message is a Binding
   Revocation Message which has a MH type <IANA-TBD> and a Binding
   Revocation Type value of 1. It is used by the initiator to inform
   the responder of the identity of a specific binding or bindings which
   IP mobility service are being revoked. Binding Revocation Indication
   message is sent as described in Section 7, Section 8.1, and
   Section 9.2.

   When the value 1 is indicated in the B. R. type field of the Binding
   Revocation Message, the format of the Binding Revocation Message Data
   follows the Binding Revocation Indication message as in Figure 5

        0   1   2   3
        0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
                                 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                                 | B.R. Type = 1 | R. Trigger |
        +-+
        | Sequence # |P|V|G| Reserved |
        +-+
        | |
        .   .
        .   Mobility options   .
        | |
        +-+
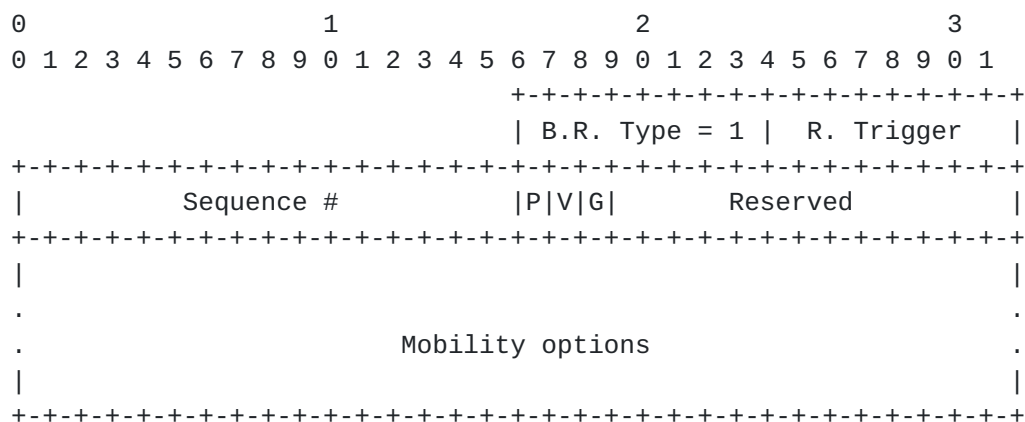

              Figure 5: Binding Revocation Indication Message

Revocation Trigger

   8-bit unsigned integer indicating the event which triggered the
   initiator to send the BRI message. The Per-MN Revocation Trigger
   values are less than 128. The per-MN revocation trigger is used
   when the BRI message intends to revoke one or more bindings for
   the same mobile node. The Global Revocation Trigger values are
   greater than 128 and less than 250 and used in the BRI message
   when the Global (G) bit is set for global revocation. The values
   250-255 are reserved for testing purposes only. The following
   Revocation Trigger values are currently defined:

   Per-MN Revocation Trigger Values:
       0 Unspecified
       1 Administrative Reason
       2 Inter-MAG Handover - same Access Type
       3 Inter-MAG Handover - different Access Type
       4 Inter-MAG Handover - Unknown
       5 User Initiated Session(s) Termination
       6 Access Network Session(s) Termination
       7 Possible Out-of Sync BCE State

   Global Revocation Trigger Values:
       128 Per-Peer Policy
       129 Revoking Mobility Node Local Policy

   Reserved Revocation Trigger Values:
       250-255 Reserved For Testing Purposes only
       All other values are Reserved

Sequence #

   A 16-bit unsigned integer used by the initiator to match a
   returned Binding Revocation Acknowledgement with this Binding
   Revocation Indication. This sequence number could be a random
   number. At any time, implementations MUST ensure there is no
   collision between the sequence numbers of all outstanding Binding
   Revocation Indication Messages.

Proxy Binding (P)

   The Proxy Binding (P) bit is set by the initiator to indicate that
   the revoked binding(s) is a PMIPv6 binding.

IPv4 HoA Binding Only (V)

   The IPv4 HoA Binding Only (V) bit is set by the initiator, home
   agent or local mobility anchor, to indicate to the receiving
   mobility entity the termination of the IPv4 Home Address binding
   only as in Section 7, and Section 8.1.

Global (G)

   The Global (G) bit is set by the initiator, LMA or MAG, to
   indicate the termination of all Per-Peer mobility Bindings or
   Multiple Bindings which share a common identifier(s) and served by
   the initiator and responder as in Section 8.1 and Section 9.2.

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. This field
   contains zero or more TLV-encoded mobility options. This document
   does not define any new mobility option. The receiver MUST ignore
   and skip any options which it does not understand. These mobility
   option(s) are used by the responder to identify the specific
   binding or bindings that the initiator requesting to be revoked.

The following options are valid in a Binding Revocation Indication:

o Home Network Prefix option [RFC5213]. This option MAY be used
   only when the (P) bit is set. This option MUST be present when
   the BRI is used to revoke a single Proxy MIPv6 binding cache
   entry.

o Mobile Node Identifier Option [RFC4283]. This option MUST be
   present when the (P) bit is set. Additionally, if the Global (G)
   bit is set by the mobile access gateway, this option MUST carry
   the MAG identity. In this specification, only Mobile Node
   Identifier option with subtype 1 is required and other subtypes
   are currently not supported.

o Binding Identifier mobility option [ID-MCoA]. This option MUST be
   present if the initiator requests to terminate one binding of a
   multiple care-of addresses bindings for the same mobile node. The
   initiator may include more than one of the BID mobility options.

o   IPv4 Home Address option which contains the mobile node home IPv4
    address [RFC5555]. This option MUST only be included when the
    IPv4 HoA Binding only (V) bit is set.

o   Alternate Care-of Address mobility option [RFC3775]. This option
    MAY be included to indicate the Care-of Address of the mobile
    node's binding that is being revoked. In the case when the Global
    (G) bit is set, this option identifies all mobility bindings that
    share the same care-of address. Additionally, if the Global (G)
    bit is set, more than one Alternate Care-of Address mobility
    options MAY be present in the Binding Revocation Indication
    message.

If no mobility options are present in this message, 4 octets of
padding are necessary and the Header Len field of the Binding
Revocation Message will be set to 1.

5.2. Binding Revocation Acknowledgement Message

The Binding Revocation Acknowledgement (BRA) message is a Binding
Revocation Message which has a MH type <IANA-TBD> and a Binding
Revocation Type value of 2. It is used to acknowledge the receipt of
a Binding Revocation Indication message described in Section 5.1.
This packet is sent as described in Section 6.1.2.

When the value 2 is indicated in the Binding Revocation type field of
the Binding Revocation Message, the format of the Binding Revocation
Message Data follows the Binding Revocation Acknowledgement message
as in Figure 6

```
        0                   1                   2                   3
        0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
                                  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                                  | B.R. Type = 2 |    Status     |
        +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
        |            Sequence #          |P|V|G|        Reserved       |
        +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
        |                                                               |
        .                                                               .
        .                       Mobility options                       .
        .                                                               .
        |                                                               |
        +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
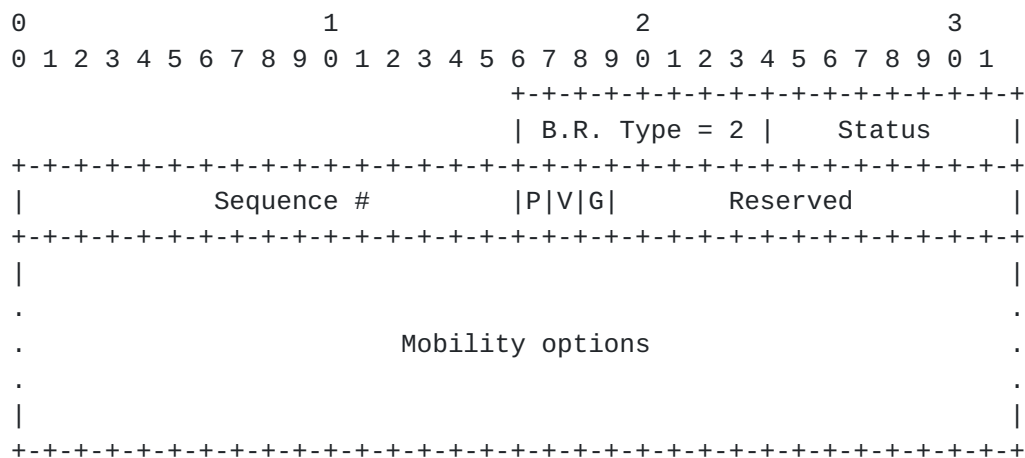
Figure 6: Binding Revocation Acknowledgement Message

Status

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

      0 success
      1 partial success
      128 Binding Does NOT Exist
      129 IPv4 Home Address Option Required
      130 Global Revocation NOT Authorized
      131 Revoked Mobile Nodes Identity Required
      132 Revocation Failed - MN is Attached
      133 Revocation Trigger NOT Supported
      134 Revocation Function NOT Supported
      135 Proxy Binding Revocation NOT Supported

Sequence #

   The sequence number in the Binding Revocation Acknowledgement is
   copied from the Sequence Number field in the Binding Revocation
   Indication. It is used by the initiator, e.g., HA, LMA, MAG, in
   matching this Binding Revocation Acknowledgement with the
   outstanding Binding Revocation Indication.

Proxy Binding (P)

   The Proxy Binding (P) bit is set if the (P) bit is set in the
   corresponding Binding Revocation Indication message.

IPv4 HoA Binding Only (V)

   The IPv4 HoA Binding Only (V) bit is set if the (V) bit is set in
   the corresponding Binding Revocation Indication message.

Global (G)

   The Global (G) bit is set if the (G) bit is set in the
   corresponding Binding Revocation Indication message.

   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. This field
      contains zero or more TLV-encoded mobility options. In the case
      when the Status field is set to success, no mobility option is
      required. The mobility option(s) is usually used to communicate
      information of the bindings that failed the revocation procedure.

   The following mobility options are valid in a Binding Revocation
   Acknowledgement:

   o Home Network Prefix option [RFC5213]. This option MAY be included
      only when the (P) bit is set.

   o Mobile Node Identifier Option [RFC4283]. This option MAY be
      included when the (P) bit is set. This option SHOULD be included
      if the Home Network Prefix option is included.

   o Binding Identifier mobility option [ID-MCoA]. The responder MAY
      include this option to indicate the specific BID that failed the
      revocation procedure.

   If no options are present in this message, 4 octets of padding are
   necessary and the Header Len field of the Binding Revocation Message
   will be set to 1.

6. Binding Revocation Process Operation

   The following subsections describe the details of the generic binding
   revocation process as used by the different mobility entities.

6.1. Sending Binding Revocation Message

   When sending a Binding Revocation message, the initiator constructs
   the packet as it would any other Mobility Header with the exception
   of setting the MH Type field to <IANA-TBD>.

   The Binding Revocation Message MUST be protected using the same
   underlying security association, e.g., IPsec, that is being used
   between the two peers to protect the mobile node's Mobile IPv6 and
   its extensions binding registration signaling. If IPsec is not used

as the underlying security mechanism to protect the binding
registration signaling, the used underlying security mechanism MUST
provide protection against all identified security threats as
described under Security Considerations in [RFC3775] and [RFC5213].

6.1.1. Sending Binding Revocation Indication

The initiator MUST construct the Binding Revocation Message Data
following the format of the Binding Revocation Indication message as
described in Section 5.1 and the following:

o The initiator MUST set the Sequence Number field to a valid
   sequence number for Binding Revocation. Since sending Binding
   Revocation Indication message is not done on a regular basis, a 16
   bit sequence number field is large enough to allow the initiator
   to match the Binding Revocation Acknowledgement to the associated
   Binding Revocation Indication using the sequence number field
   only.

o If the initiator is revoking a binding that was created using
   proxy MIPv6 registration, the initiator MUST set the Proxy Binding
   (P) bit.

o If the initiator is sending the Binding Revocation Indication
   message to revoke multiple mobility sessions, the initiator MUST
   set the Global (G) bit. In this case, the initiator MUST set the
   revocation trigger field to a valid value from the list of Global
   Revocation Triggers.

o If the initiator is sending the Binding Revocation Indication
   message with the Global (G) bit cleared, the initiator MUST set
   the revocation trigger field to a valid value from the list of
   per-MN Revocation Triggers.

o If the initiator is sending the Binding Revocation Indication
   message to indicate the revocation of the mobile node IPv4 HoA
   Binding Only, the initiator MUST set the (V) bit. In this case,
   the initiator MUST include the IPv4 Home Address option in the BRI
   to identify the IPv4 HoA that is being revoked.

6.1.2. Sending Binding Revocation Acknowledgement

The responder MUST send a Binding Revocation Acknowledgement message
to indicate the receipt and the status of processing of the
corresponding Binding Revocation Indication message as follows:

o Whenever the Binding Revocation Indication is discarded, e.g., as
   described in Section 6.2, a Binding Revocation Acknowledgement
   MUST NOT be sent. Otherwise the treatment depends on the
   following rules.

o If the responder accepts the Binding Revocation Indication
   message, the responder MUST send a successful Binding Revocation
   Acknowledgement with an appropriate status code.

o If the responder rejects the Binding Revocation Indication
   message, the responder MUST send a Binding Revocation
   Acknowledgement with an appropriate failure status code.

If the Source Address field of the IPv6 header that carried the
Binding Revocation Indication message does not contain a unicast
address, the Binding Revocation Indication packet MUST be silently
discarded.

When the responder acknowledges the received Binding Revocation
Indication message, the responder MUST construct the Binding
Revocation Message Data following the format of the Binding
Revocation Acknowledgement message as described in Section 5.2 and
the following:

o The responder MUST set the Sequence Number field by copying the
   value from the Sequence Number field of the received Binding
   Revocation Indication.

o The responder MUST set the status field to a valid value that
   reflects the status of the processing of the received Binding
   Revocation Indication message.

o If the (P) bit is set in the received Binding Revocation
   Indication, the responder MUST set the (P) bit in the Binding
   Revocation Acknowledgement.

o If the Global (G) bit is set in the received Binding Revocation
   Indication, the responder MUST set the Global (G) bit in the
   Binding Revocation Acknowledgement.

o If the IPv4 HoA Binding Only (V) bit is set in the received
   Binding Revocation Indication, the responder MUST set the (V) bit
   in the Binding Revocation Acknowledgement.

o The destination IP address of the IPv6 packet of the Binding
   Revocation Acknowledgement is set to the source IP address of the
   received Binding Revocation Indication.

6.2. Receiving Binding Revocation Message

   When receiving a Binding Revocation message, the responder MUST
   verify the Mobility Header as described in section 9.2. of [RFC3775].
   If the packet is dropped due to failing any of the Mobility Headers
   test check, the responder MUST follow the processing rules as in
   Section 9.2 of [RFC3775]. If the responder does not support the
   Binding Revocation Indication message and does not recognize the MH
   type <IANA-TBD>, it sends a Binding Error message with the Status
   field set to 2 as described in [RFC3775].

   Upon receiving a packet carrying a Binding Revocation Message, BRI or
   BRA, the receiving mobility entity MUST verify that the packet was
   received protected by the security association that is being used to
   protect the binding registration and Binding Revocation signaling
   between the two peers, e.g., an IPsec SA.

6.2.1. Receiving Binding Revocation Indication

   When the responder receives a packet carrying a Binding Revocation
   Indication message that was successfully processed as in Section 6.2,
   the responder, in addition, processes the message as follows:

   o The responder MUST validate that the Binding Revocation Indication
      is formatted as in Section 5.1.

   o If the Revocation Trigger field is set to a value that the
      responder does not support, the responder SHOULD reject the
      Binding Revocation Indication message using status code
      "Revocation Trigger NOT Supported".

   o If the Revocation Trigger value is NOT allowed with the Binding
      Revocation Indication message intent, e.g., the Global (G) bit is
      set and the Revocation Trigger field value is a per-MN specific,
      the responder SHOULD reject the Binding Revocation Indication
      message using status code "Revocation Function NOT Supported".

   o If the responder failed to identify the mobile node(s) bindings as
      identified in the Binding Revocation Indication message, the
      responder MUST reject the BRI using Status code "Binding Does NOT
      Exist".

6.2.2. Receiving Binding Revocation Acknowledgement

   When the initiator receives a packet carrying a Binding Revocation
   Acknowledgement message that was successfully processed as in
   Section 6.2, the initiator, in addition, processes the message and
   examines the Status field as follows:

o The initiator MUST validate that the sequence number in the
   Sequence Number field matches the sequence number of an
   outstanding Binding Revocation Indication that was sent by the
   initiator. If the sequence number does not match a sequence
   number of any of the outstanding Binding Revocation Indication
   messages, the initiator MUST silently discard the message but MAY
   log the event.

o If the Status field indicates that the Binding Revocation
   Indication was processed successfully, the initiator MUST delete
   the current timer and the mobile node(s) binding(s) and all
   associated resources.

o If the Status field indicates any value other than success, the
   initiator SHOULD examine any mobility options included in the
   Binding Revocation Acknowledgement. In this case, it is based on
   the initiator local policy how to handle the mobile node binding.
   The initiator MAY log the appropriate event to reflect the
   received status.

6.3. Retransmission of Binding Revocation Indication

If the initiator does not receive a Binding Revocation
Acknowledgement in response to the outstanding Binding Revocation
Indication before the InitMINDelayBRIs timer expires, the initiator,
e.g. LMA, SHOULD retransmit the same BRI message up to the
BRIMaxRetriesNumber as defined in Section 11.

The retransmissions by the initiator MUST use an exponential back-off
process in which the timeout period is doubled upon each
retransmission, until either the initiator receives a response or the
timeout period reaches the value MAX_BRACK_TIMEOUT. The initiator
MAY continue to send these messages at this slower rate up to the
BRIMaxRetriesNumber.

If the initiator does not receive a Binding Revocation
Acknowledgement message after the BRIMaxRetriesNumber of retransmits
have been sent, the initiator SHOULD clean all resources associated
with this mobile node binding. The initiator may log the event.

7. Home Agent Operation

To terminate a mobile node registration and its current binding with
the home agent, the home agent sends a packet to the mobile node
containing a Binding Revocation Indication, with the packet
constructed as follows:

o The Revocation Trigger field MUST be set to indicate to the mobile
   node the reason for revoking its IP mobility binding with the home
   agent. The Revocation Trigger may be used by the mobile node to
   take further steps if necessary.

o The Binding Revocation Indication MUST be sent using a Type 2
   routing header which contains the mobile node's registered IPv6
   home address for the binding being revoked.

o The care-of address for the binding MUST be used as the
   destination address in the packet's IPv6 header, unless an
   Alternate Care-of Address mobility option is included in the
   Binding Revocation Indication. If an Alternate Care-of Address
   option is included in the Binding Revocation Indication message,
   the destination address in the packet's IPv6 header SHOULD be set
   to the source IP address of the packet that carried the latest
   successful Binding Update with the Alternate Care-of address
   included.

o If the home agent needs to only revoke the mobile node's IPv4 home
   address binding, the home agent MUST set the IPv4 HoA Binding Only
   (V) bit and MUST include the mobile node's registered IPv4 home
   address that is being revoked in the IPv4 Home Address option.

When the home agent sends a Binding Revocation Indication to the
mobile node, the home agent sets a flag in the mobile node BCE to
indicate that revocation is in progress and starts the
InitMINDelayBRIs timer. The home agent maintains the mobile node BCE
in this state until it receives a Binding Revocation Acknowledgement
or retransmits the Binding Revocation Indication message as described
in Section 6.3.

In a race condition case, the home agent may receive a Binding Update
from the mobile node while the mobile node's BCE has the revocation
in progress flag set, the home agent SHOULD handle this case based on
the reason for sending the Binding Revocation Indication message and
its local policy. In this case, if the home agent accepts the
Binding Update, it needs to update the mobile node BCE accordingly,
e.g. removing the revocation in progress flag.

When the home agent needs to revoke one or more of a mobile node
bindings that were created using Multiple Care-of address
registration as in [ID-MCoA], the home agent MUST include all the
related BID mobility options that identify these bindings in the
Binding Revocation Indication message. In the case when the home
agent needs to revoke all of the mobile node bindings, the home agent
SHOULD NOT include any of the BID mobility options.

When the home agent receives a packet carrying a valid Binding
Revocation Acknowledgement message, the home agent follows
Section 6.2 in processing this message.

8. **Local Mobility Anchor Operation**

8.1. **Sending Binding Revocation Indication**

To terminate a mobile node PMIPv6 registration and its current
binding with the local mobility anchor, the local mobility anchor
sends a packet to the mobile access gateway containing a Binding
Revocation Indication message following the procedure in Section 6.1
and the following rules:

o The Proxy Mobile IP (P) bit MUST be set to indicate that the
   binding being revoked is a PMIPv6 binding.

o The Revocation Trigger field MUST be set to indicate to the mobile
   access gateway the reason for removing the specified mobile node
   PMIPv6 binding at the local mobility anchor. The Revocation
   Trigger may be used by the mobile access gateway to learn the
   mobile node's latest movement.

o The packet MUST contain the Mobile Node Identifier, MN-ID, option
   which contains the mobile node's NAI that was used in the Proxy
   Binding Update during the mobile node registration.

o If the Mobile Node Identifier, MN-ID, is registered in more than
   one of the mobile node's BCE and the local mobility anchor does
   NOT need to revoke all of the mobile node's bindings, the Binding
   Revocation Indication message MUST contain another identifier to
   uniquely identify the mobile node binding(s) that is being
   revoked, e.g., at least one Home Network Prefix option which
   contains the mobile node's registered Home Network Prefix (HNP)
   for the binding being revoked.

o In case of revoking all Per-Peer bindings, the local mobility
   anchor MUST set the Global (G) bit and the Revocation Trigger MUST
   contain the value "Per-Peer Policy" to request the mobile access
   gateway to remove all Per-Peer bindings that are registered with
   the local mobility anchor and this mobile access gateway.

o The care-of address for the binding MUST be used as the
   destination address in the packet's IPv6 header, unless an
   Alternate Care-of Address mobility option is included in the
   Binding Revocation Indication message. If an Alternate Care-of
   Address option is included in the Binding Revocation Indication

message, the destination address in the packet's IPv6 header
SHOULD be set to the source IP address of the packet that carried
the latest successful Proxy Binding Update with the Alternate
Care-of address included.

The local mobility anchor MAY delete the mobile node(s) IP tunnel
immediately after sending the initial Binding Revocation Indication
and before receiving the Binding Revocation Acknowledgement message.

When the local mobility anchor sends a Binding Revocation Indication
to the mobile access gateway to remove a specific binding, the local
mobility anchor sets a flag in the mobile node proxy BCE to indicate
that revocation is in progress and starts the InitMINDelayBRIs timer.
The local mobility anchor SHOULD maintain the mobile node proxy BCE
in this state until it receives a Binding Revocation Acknowledgement
or the BRIMaxRetransmitNumber is reached. In the case when the local
mobility anchor sets the Revocation Trigger field to a value which
indicates inter-MAG handover, the local mobility anchor MAY switch
the mobile node IP tunnel to the target mobile access gateway before
sending the Binding Revocation Indication to the source mobile access
gateway.

In a race condition case, the local mobility anchor may receive a
Proxy Binding Update from the mobile access gateway while the mobile
node's proxy BCE has the revocation in progress flag set. The local
mobility anchor should handle this case based on the reason for
sending the Binding Revocation Indication message and its local
policy. In this case, if the local mobility anchor accepts the Proxy
Binding Update, it needs to update the mobile node proxy BCE
accordingly, e.g. removing the revocation in progress flag.

When the local mobility anchor needs to revoke all the mobile nodes
proxy BCEs that are registered with the local mobility anchor and the
mobile access gateway peer, it MUST set the Global (G) bit and set
the value of the Revocation Trigger field to "Per-Peer Policy". In
this case, the local mobility anchor MUST NOT include any mobility
options in this Binding Revocation Indication message.

When the local mobility anchor needs to revoke all mobile nodes proxy
BCEs that belong to a specific realm and are registered with the
local mobility anchor and the mobile access gateway peer, the local
mobility anchor MUST set the Global (G) bit and set the value of the
Revocation Trigger field to "Revoking Mobility Node Local Policy".
In this case, the local mobility anchor MUST include a mobility
option in the Binding Revocation Indication that is shared among all
the impacted mobile nodes BCEs, e.g., the mobile node identifier
option, MN-ID option, with subtype value of 1. In this case, the NAI

value in the MN-ID MUST follow the format where the content after the "@" character defines the realm which is shared amongst all of the impacted mobile nodes proxy BCEs. As an example: @example.com identifies all mobile nodes which their MN-ID value contain "example.com" as the realm, e.g., "1234abdelta@example.com", "axxxyzd@example.com", and "abcdefg.xyz123@example.com", but not "1234abdelta@foo.example.com".

When the local mobility anchor needs to revoke a subgroup of the mobile nodes proxy BCEs that belong to a specific realm and are registered with the local mobility anchor and the mobile access gateway, the local mobility anchor MUST set the Global (G) bit and set the value of the Revocation Trigger field to "Revoking Mobility Node Local Policy". In this case, the local mobility anchor MUST include an additional mobility option to the mobile node identifier option, MN-ID option, with subtype value of 1. In other words, the impacted mobile node BCEs are those which have a MN-ID with a realm as specified above and, e.g., are assigned the same proxy care-of address as the one included in the Alternate Care-of address mobility option.

When the mobile node is registered with multiple Home Network Prefixes for the same proxy care-of address, the local mobility anchor SHOULD include a HNP option for each registered HNP in the Binding Revocation Indication. Alternatively, it MAY include only the mobile node identifier, MN-ID, option with the mobile node NAI included to indicate to the mobile access gateway to remove all bindings of the specified mobile node NAI in the MN-ID option.

According to Proxy Mobile IPv6 specification [RFC5213], if the local mobility anchor receives a Proxy Binding Update message from a new mobile access gateway for extending the binding lifetime of the only BCE of this mobile node with the Handoff Indicator value is set to "Inter-MAG Handover - Unknown", the local mobility anchor waits a period of MaxDelayBeforeNewBCEAssign to receive a de-registration message from the previous mobile access gateway before updating the mobile node's BCE with the new point of attachment. If a de-registration message is not received, the local mobility anchor considers the received Proxy Binding Update message as a request for a new BCE and if processed successfully, the local mobility anchor assigns a different HNP for the new BCE.

This document updates the local mobility anchor's behavior in this case. If the local mobility anchor supports the binding revocation mechanism as described in this document, it SHOULD proactively send a Binding Revocation Indication message to the previous mobile access gateway instead of waiting for a de-registration from the previous mobile access gateway. In the Binding Revocation Indication message,

the Revocation Trigger MUST be set to "Inter-MAG Handover - Unknown".

If the local mobility anchor sent a Binding Revocation Indication message with the Revocation Trigger field set to "Inter-MAG Handover - Unknown" and while waiting for a Binding Revocation Acknowledgement, the following are possible conditions that the local mobility anchor MUST handle as specified below:

o If the local mobility anchor receives a successful Binding Revocation Acknowledgement message or a de-registration message from the previous mobile access gateway, the local mobility anchor MUST update the mobile node BCE in a similar way as if it received a de-registration message as described in [RFC5213].

o If the local mobility anchor receives a Binding Revocation Acknowledgement message with the status field set to "Revocation Failed - MN is Attached", the local mobility anchor SHOULD update the mobile node BCE in a similar way as if it did NOT receive a de-registration before the MaxDelayBeforeNewBCEAssign timer expires by creating a new BCE as described in [RFC5213].

o If the local mobility anchor did not receive a Binding Revocation Acknowledgement message nor a de-registration Proxy Binding Update from the previous mobile access gateway after it exhausted all of the Binding Revocation Indication message retransmissions as described in Section 6.3, the local mobility anchor SHOULD update the mobile node's BCE in a similar way as if it did NOT receive a de-registration before the MaxDelayBeforeNewBCEAssign timer expires by creating a new BCE as described in [RFC5213]. Note that the local mobility anchor SHOULD use the recommended number of retransmissions for the Binding Revocation Indication message as described in Section 11 to avoid delaying the creation of a new binding cache entry for too long, if the mobile node is actually attaching to the new MAG with a different interface.

When the mobile node is registered with an IPv4 proxy home address in addition to the Home Network Prefix where both of the IPv4 pHoA and HNP are bound to the same proxy CoA, the local mobility anchor MAY revoke the mobile node IPv4 proxy HoA binding to the current mobile node proxy CoA while maintaining the mobile node binding of the HNP to its current pCoA as part of the mobile node BCE. In this case, if the local mobility anchor decides to revoke the mobile node IPv4 proxy HoA only, it MUST send a Binding Revocation Indication message following the procedure in Section 6.1 and the following rules:

o The IPv4 HoA Binding Only (V) bit MUST be set in the BRI to
   indicate that only the IPv4 home address binding is being revoked.

o The IPv4 Home Address option MUST be included with the mobile
   node's registered IPv4 home address that is being released in
   addition to the MN-ID option.

o The mobile node Home Network Prefix option MUST NOT be included.

o The Revocation Trigger field MUST be set to an appropriate value,
   e.g. "User Initiated Session(s) Termination".

8.2. Receiving Binding Revocation Indication

When the local mobility anchor receives a packet carrying a Binding
Revocation Indication that was successfully processed as in
Section 6.2, in addition, the local mobility anchor processes the
message as follows:

o If the (P) bit is set, the local mobility anchor MUST validate
   that all impacted binding(s) have the proxy binding flag set.

o If the Global (G) bit is set and the Revocation Trigger field
   value is "Per-Peer Policy", the LMA MUST validate that the Proxy
   (P) bit is set and the MN-ID option is present with the mobile
   access gateway identity included. In addition, the local mobility
   anchor MUST verify that the identified mobile access gateway as
   per the value in the MN-ID option is authorized to use the global
   revocation with revocation trigger value "Per-Peer Policy", see
   Section 13. If the local mobility anchor processes the Global
   Binding Revocation Indication message successfully, it MUST accept
   the Binding Revocation Indication message using the Status code
   success.

o If the mobile access gateway is not authorized to use the Per-Peer
   Global revocation feature or the received Binding Revocation
   Indication message has the Global (G) bit set and the Revocation
   Trigger field is set to "Per-Peer Policy", but the MN-ID option is
   not included, the local mobility anchor MUST reject the Binding
   Revocation Indication message using Status code (Global Revocation
   NOT Authorized).

o If the Global (G) bit is set and the Revocation Trigger value is
   "Per-Peer Policy", and only the mobile node identifier, MN-ID,
   option is included, the local mobility anchor MUST revoke all
   mobile nodes bindings which proxy CoA is the one used as the
   source of the IPv6 packet that carried the Binding Revocation
   Indication. However, if one or more Alternate Care-of Address

options are included in addition to the mobile node identifier
option, the local mobility anchor MUST revoke all mobile nodes
bindings which proxy Care-of Address matches one of the Care-of
address(es) in the Alternate Care-of Address option(s). After the
local mobility anchor successfully processes the Binding
Revocation Indication message and identifies all impacted mobile
nodes bindings, it MUST accept the Binding Revocation Indication
message using the Status code success.

o If the local mobility anchor accepted the Binding Revocation
   Indication message but one or more of the bindings identified in
   the received Binding Revocation Indication message has already
   been released, the local mobility anchor MUST accept the message
   and it MAY set the Status field to (partial success) and include
   the mobile node identifier, MN-ID, or the Home Network Prefix
   option to identify the binding(s) that failed the revocation
   procedure.

o If the Global (G) bit is not set, the local mobility anchor uses
   the included mobility options to identify the impacted mobile node
   binding as follows:

   1. If only the mobile node identifier, MN-ID, option is included,
       the local mobility anchor MUST accept the message and revoke
       all bindings for this mobile node which use the specified
       mobile node NAI including the IPv4 Home Address binding(s) if
       present.

   2. If the mobile node identifier, MN-ID, and one Home Network
       Prefix option are included, the local mobility anchor MUST
       accept the message and only remove the specified mobile node
       proxy binding.

   3. If the mobile node identifier, MN-ID, option and more than one
       Home Network Prefix options are included, the local mobility
       anchor MUST accept the message and remove all bindings which
       are referenced by these Home Network Prefixes for the
       specified mobile node NAI.

   4. If the IPv4 HoA binding Only (V) bit is set and the mobile
       node identifier, MN-ID, option and the IPv4 Home Address
       option are included, the local mobility anchor MUST accept the
       message and remove only the IPv4 HoA address binding to the
       mobile node current proxy Care-of address.

The Revocation Trigger field value in the received Binding Revocation
Indication could be used by the local mobility anchor to log an event
or update some local parameters which tracks the state of the peer

mobile access gateway.

After the local mobility anchor accepts or rejects a Binding
Revocation Indication message, the local mobility anchor MUST follow
Section 6.1 and Section 6.1.2 to send a Binding Revocation
Acknowledgement message to the mobile access gateway.

9. Mobile Access Gateway Operation

9.1. Receiving Binding Revocation Indication

When the mobile access gateway receives a packet carrying a Binding
Revocation Indication that was successfully processed as in
Section 6.2, in addition, the mobile access gateway processes the
message as follows:

o If the Global (G) bit is set and the Revocation Trigger field
   value is "Per-Peer policy", the mobile access gateway MUST
   validate that the Proxy (P) bit is set and no mobility options is
   included in the message. If the mobile access gateway processes
   the Global Binding Revocation Indication message successfully, it
   MUST accept the Binding Revocation Indication message using the
   Status code success.

o If the Global (G) bit is set and the Revocation Trigger field
   value is "Revoking Mobility Node Local Policy", the mobile access
   gateway MUST validate that the Proxy (P) bit is set and at least
   the MN-ID option with the subtype value of 1 is included in the
   Binding Revocation Indication and it is formatted as described is
   Section 8.1. If the mobile access gateway processes this Global
   Binding Revocation Indication message successfully, it MUST accept
   the message using the Status code success.

o If the Global (G) bit is set and the Revocation Trigger field
   value is "Revoking Mobility Node Local Policy", and no mobility
   options are included in the Binding Revocation Indication message
   or the mobile access gateway is not able to identify the impacted
   mobile nodes bindings based on the included mobility options, the
   mobile access gateway MUST treat this as an error scenario. In
   this case, the mobile access gateway MUST reject the Binding
   Revocation Indication message using Status code "Revoked Mobile
   Nodes Identity Required".

o If the Revocation Trigger field value in the received Binding
   Revocation Indication message indicates inter-MAG handover, e.g.,
   Inter-MAG Handover - Unknown, the mobile access gateway uses the

mobility option(s) included in the Binding Revocation Indication message to identify the mobile node binding. The mobile access gateway SHOULD ensure that the mobile node is no longer attached to the mobile access gateway before accepting the BRI message using Status code success. However, if the mobile access gateway verified that the mobile node is still directly attached, the mobile access gateway MUST reject the BRI using Status code "Revocation failed - MN is Attached".

o If the IPv4 HoA Binding Only (V) bit is set, the mobile access gateway uses the MN-ID option to identify the mobile node binding entry in the Binding Update List (BUL). The mobile access gateway MUST verify that the IPv4 address included in the IPv4 Home Address option in the received Binding Revocation Indication is the same as the IPv4 proxy HoA that is assigned to the mobile node. After the mobile access gateway successfully validates the received IPv4 home address as the mobile node IPv4 HoA, it MUST consider this as an indication to ONLY release the mobile node IPv4 proxy HoA binding to the mobile node current proxy CoA. Consequently, it MUST continue to maintain the mobile node IPv6 proxy HoA or HNP binding to the current mobile node proxy CoA as part of the mobile node binding in the BUL entry and release all resources associated with the MN IPv4 proxy HoA binding to the MN pCoA. If the mobile access gateway processed the BRI successfully, the mobile access gateway MUST accept the BRI using Status code success. On the other hand, if the mobile access gateway is able to identify the mobile node binding using the MN-ID but failed to identify the received IPv4 proxy HoA, the mobile access gateway MUST reject the BRI using Status code "Binding Does NOT Exist".

o If the mobile access gateway accepts the Binding Revocation Indication message but one or more of the bindings identified in the received Binding Revocation Indication message has already been released before processing the Binding Revocation Indication, the mobile access gateway MUST accept the Binding Revocation Indication message. In this case, the mobile access gateway MAY set the Status field to "partial success" and include the mobile node identifier, MN-ID, or the Home Network Prefix option to identify the binding(s) that failed to be removed as part of the revocation procedure.

The Revocation Trigger field value in the received Binding Revocation Indication could be used by the mobile access gateway to define what actions the mobile access gateway could do to inform the mobile node that its IP connectivity to the current HNP has been terminated, e.g., if the Revocation Trigger field is set to "Administrative Reason", the mobile access gateway may send a RA message after

setting the Home Network Prefix valid lifetime to zero.

After the mobile access gateway accepts or rejects a Binding Revocation Indication message, the mobile access gateway MUST follow Section 6.1 and Section 6.1.2 to send a Binding Revocation Acknowledgement message to the local mobility anchor.

9.2. Sending Binding Revocation Indication

The mobile access gateway could send a Binding Revocation Indication message to indicate the termination of multiple mobile node bindings, e.g., when using the global revocation with the Global (G) bit is set. In this case when an event occurs which requires the mobile access gateway to inform the local mobility anchor peer to terminate all mobile nodes bindings which are registered at the local mobility anchor and the mobile access gateway, the mobile access gateway sends a Binding Revocation Indication message following the procedure in Section 6.1 and the followings:

o The Proxy Binding (P) bit MUST be set to indicate that the binding(s) being revoked is a PMIPv6 binding.

o The Global (G) bit MUST be set and the Revocation Trigger MUST contain a value of "Per-Peer Policy" in the Binding Revocation Indication to request the local mobility anchor to remove all Per-Peer bindings that are registered with the local mobility anchor and the mobile access gateway. In this case, the MN-ID option MUST be included in the Binding Revocation Indication and contain the mobile access gateway identity. In addition, the mobile access gateway MAY include one or more Alternate Care-of Address option(s). The Alternate Care-of Address option(s) contain the proxy Care-of address(es) the bindings of which are being impacted by this Binding Revocation Indication message.

o The mobile access gateway address MAY be used as the source address in the packet's IPv6 header.

As described in Section 6.3, the mobile access gateway SHOULD retransmit the Binding Revocation Indication to the local mobility anchor until it receives a matching Binding Revocation Acknowledgement or the BRIMaxRetransmitNumber is reached. The mobile access gateway MAY delete the mobile nodes IP tunnels immediately after sending the Binding Revocation Indication and before receiving a Binding Revocation Acknowledgement message from the LMA.

In a response to a Binding Revocation Indication message, if the mobile access gateway receives a packet carrying a Binding Revocation

Acknowledgement that was successfully processed as in Section 6.2 and
the Status field indicates (Global Revocation NOT Authorized), the
mobile access gateway is not authorized to participate in a Per-Peer
Global Revocation. The mobile access gateway SHOULD NOT retry
sending a Binding Revocation Indication with the Global (G) bit is
set and the Revocation Trigger field value is set to "Per-Peer
Policy" to the same local mobility agent. The mobile access gateway
should raise an alarm or log an event to indicate this rejection.

10. Mobile Node Operation

Upon receiving a packet carrying a Binding Revocation Indication, the
mobile node MUST validate the packet according to Section 6.2 and the
following tests:

o   The mobile node MUST verify that the IP address in the Type 2
    routing header is its Home Address and that its Binding Update
    List contains an entry for that Home Address. If one of the tests
    fails, the mobile node SHOULD silently discard the received
    Binding Revocation Indication message.

o   If mobile node Binding Update List contains an entry for the IP
    address in the Type 2 routing header of the received Binding
    Revocation Indication packet, the mobile node MUST accept the BRI
    message using Status code success.

o   If the IPv4 HoA Binding Only (V) bit is set in the received BRI
    message, the mobile node MUST verify that there is an IPv4 Home
    Address option in the received Binding Revocation Indication and
    the IPv4 address included in the IPv4 Home Address option is the
    same as its IPv4 HoA that is assigned to the mobile node. If this
    verification is successful, the mobile node MUST consider this
    Binding Revocation Indication as an indication to ONLY release the
    mobile node IPv4 HoA binding to its current Care-of Address.
    Consequently, the mobile node MUST continue to maintain its IPv6
    HoA binding to the current CoA as part of the mobile node binding
    in the BUL entry and release all resources associated with the MN
    IPv4 HoA binding. In this case, the mobile node MUST accept the
    Binding Revocation Indication message using Status code success.
    On the other hand, if the IPv4 Home Address Option was NOT
    included in the received BRI with the (V) bit is set, the MN MUST
    reject the BRI message with Status code "IPv4 Home Address Option
    Required". Additionally, if the IPv4 HoA received in the IPv4
    Home Address Option is NOT the one assigned to the mobile node,
    the mobile node SHOULD reject the Binding Revocation Indication
    with Status code "Binding Does NOT Exist".

o The mobile node MUST verify that the (P) bit in the Binding
   Revocation Indication is NOT set. If the (P) bit is set, the
   mobile node MUST reject the Binding Revocation Indication using
   Status code "Proxy Binding Revocation NOT Supported".

o If the mobile node has registered multiple care-of addresses with
   its home agent, the mobile node MUST verify which binding is being
   revoked by examining the content of the Binding Revocation
   Indication message. If the mobile node received a Binding
   Revocation Indication with a single or more than one BID options
   and its home address is included in the Type 2 routing header, the
   mobile node MUST consider all of the care-of address(es)
   binding(s), identified in the BID options, with this home address
   as being revoked. In this case, if the BRI validation is
   successful, the mobile node MUST accept the Binding Revocation
   Indication message with Status code success.

o If the mobile node has multiple Care-of Address bindings with its
   home agent and received a Binding Revocation Indication, without
   any BID option included and its home address was included in the
   Type 2 routing header, the mobile node MUST consider all of its
   registered care-of addresses bindings with this home address as
   being revoked. If the mobile node validates the BRI successfully,
   the mobile node MUST accept the Binding Revocation Indication
   message with Status code success.

If the mobile node accepts or rejects the Binding Revocation
Indication message, the mobile node MUST follow Section 6.1 and
Section 6.1.2 to send a Binding Revocation Acknowledgement message to
the home agent. Note that anytime the MN does not send a Binding
Revocation Acknowledgement to a BRI, the initiator is likely to
retransmit the BRI at least one time. This causes additional load on
the initiator who sends the retransmissions, as well as on the MN
that will receive and process them.

The Revocation Trigger field value in the received Binding Revocation
Indication could be used by the mobile node to define what action the
mobile node could do to be able to register again and receive its IP
mobility service, e.g., contacting its home operator.

11. Protocol Configuration Variables

Any mobility entity which is allowed to invoke the binding revocation
procedure by sending a Binding Revocation Indication message SHOULD
allow the following variables to be configured.

BRI Maximum Number of Retries (BRIMaxRetriesNumber)

   This variable specifies the maximum Number of times a mobility
   entity can retransmit a Binding Revocation Indication message
   before receiving a Binding Revocation Acknowledgement message.
   The default value for this parameter is 1.

Initial Minimum Delay Between BRI messages (InitMINDelayBRIs)

   This variable specifies the initial delay timeout in seconds
   before the revoking mobility entity retransmits a BRI message.
   The default is 1 second but not less than 0.5 seconds.

Maximum BRA TIMEOUT (MAX_BRACK_TIMEOUT)

   This variable specifies the maximum delay timeout in seconds
   before the revoking mobility entity retransmits a BRI message.
   The default is 2 seconds.

12. IANA Considerations

This specification defines a new Binding Revocation Message using a
new Mobility Header Type <IANA-TBD>, as described in Section 5. The
new Mobility Header type value needs to be assigned from the same
numbering space as allocated for the other Mobility Header types
registry.

This document also creates a new registry "Binding Revocation Type"
which indicates the type of the binding revocation message. The
current binding revocation message types are described in Section 5.1
and Section 5.2, and are the following:

     0 Reserved
     1 Binding Revocation Indication
     2 Binding Revocation Acknowledgement
     All other values are reserved

Future values of the Binding Revocation Type can be allocated using
Standards Action or IESG Approval [RFC5226].

In addition, this document also creates a second new registry for the
Revocation Trigger which indicates the reason behind sending the
Binding Revocation Indication message. The current Revocation
Trigger values are described in Section 5.1, and are the following:

Per-MN Revocation Trigger Values:

```
    0   Unspecified
    1   Administrative Reason
    2   Inter-MAG Handover - same Access Type
    3   Inter-MAG Handover - different Access Type
    4   Inter-MAG Handover - Unknown
    5   User Initiated Session(s) Termination
    6   Access Network Session(s) Termination
    7   Possible Out-of Sync BCE State
```

   Global Revocation Trigger Values:
```
    128  Per-Peer Policy
    129  Revoking Mobility Node Local Policy
```

   Reserved Revocation Trigger Values:
```
    250-255 Reserved For Testing Purposes only
    All other values are Reserved
```

   Future values of the Revocation Trigger can be allocated using
   Standards Action or IESG Approval [RFC5226].

   Furthermore, this document creates a third new registry "Status Code"
   for the Status field in the Binding Revocation Acknowledgement
   message. The current values are described in Section 5.2, and are
   the following:

```
    0   success
    1   partial success
    128  Binding Does NOT Exist
    129  IPv4 Home Address Option Required
    130  Global Revocation NOT Authorized
    131  Revoked Mobile Nodes Identity Required
    132  Revocation Failed - MN is Attached
    133  Revocation Trigger NOT Supported
    134  Revocation Function NOT Supported
    135  Proxy Binding Revocation NOT Supported
```

   Future values of the Status field can be allocated using Standards
   Action or IESG Approval [RFC5226].

   All fields labeled "Reserved" are only to be assigned through
   Standards Action or IESG Approval.

13. Security Considerations

   This specification allows the mobility node which initiates the
   binding revocation procedure to revoke mobility session(s) that is
   currently registered with it. It is NOT allowed for any mobility

node to revoke a mobile node mobility session that is not registered
with this mobility node.

The binding revocation protocol described in this specification uses
the same security association between the mobile node and the home
agent or the mobile access gateway and the local mobility anchor that
is being used to exchange the MIPv6 or PMIPv6 Binding Update and
Binding Acknowledgement signaling. If IPsec is used, the traffic
selectors associated with the SPD entry protecting the Binding Update
and Binding Acknowledgement MUST be extended to include Binding
Revocation Message MH type <IANA-TBD>. Extending the traffic
selectors of the SPD entry in order to reuse the SA protecting the
Binding Update and Binding Acknowledgement (instead of creating new
ones) ensures that those SA will be up and running when the revoking
entity needs to send a binding revocation signaling message.

On the other hand, if IPsec is not used as the underlying security
mechanism to protect the Mobile IPv6 and its extensions binding
registration signaling, the used underlying security mechanism MUST
provide protection against all identified security threats as
described under Security Considerations in [RFC3775] and [RFC5213].

Since some mobility entities, e.g., local mobility anchor and mobile
access gateway, are allowed to send and receive Binding Revocation
Indication and Binding Revocation Acknowledgement for different
cases, therefore, when IPsec is used to secure signaling between the
local mobility anchor and mobile access gateway, it prevents any of
them from processing a Binding Revocation Message that was not
constructed by an authorized party.

The Proxy Mobile IPv6 [RFC5213] requires the local mobility anchor to
restrict the creation and manipulation of proxy bindings to
specifically authorized mobile access gateways. Therefore, the
mobile access gateway which is authorized to create or manipulate the
mobile node proxy BCE is also authorized to revoke such mobile node
registration by sending a de-registration with lifetime of zero.
However, since bulk termination using Binding Revocation Indication
with the Global (G) bit set and the Revocation Trigger field set to
"Per-Peer Policy" impacts all mobility sessions that are registered
with the mobile access gateway and its local mobility anchor peer,
the local mobility anchor MUST be locally configurable to authorize
such specific functionality. Additional mechanisms, such as a policy
store or Authentication, Authorization, and Accounting (AAA) may be
employed, but these are outside the scope of this specification.

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Authors' Addresses

   Ahmad Muhanna
   Nortel
   2221 Lakeside Blvd.
   Richardson, TX 75082
   USA

   Email: amuhanna@nortel.com

   Mohamed Khalil
   Nortel
   2221 Lakeside Blvd.
   Richardson, TX 75082
   USA

   Email: mkhalil@nortel.com

   Sri Gundavelli
   Cisco Systems
   170 West Tasman Drive
   San Jose, CA 95134
   USA

   Email: sgundave@cisco.com

   Kuntal Chowdhury
   Starent Networks
   30 International Place
   Tewksbury, MA 01876
   USA

   Email: kchowdhury@starentnetworks.com

Parviz Yegani
Juniper Networks
1194 North Mathilda Avenue
Sunnyvale, CA 94089
USA

Email: pyegani@juniper.net