             Mobile IPv6 Fast Handovers for 3G CDMA Networks
                     draft-ietf-mipshop-3gfh-07.txt

Status of this Memo

   By submitting this Internet-Draft, each author represents that any
   applicable patent or other IPR claims of which he or she is aware
   have been or will be disclosed, and any of which he or she becomes
   aware will be disclosed, in accordance with Section 6 of BCP 79.

   Internet-Drafts are working documents of the Internet Engineering
   Task Force (IETF), its areas, and its working groups. Note that
   other groups may also distribute working documents as Internet-
   Drafts.

   Internet-Drafts are draft documents valid for a maximum of six months
   and may be updated, replaced, or obsoleted by other documents at any
   time. It is inappropriate to use Internet-Drafts as reference
   material or to cite them other than as "work in progress."

   The list of current Internet-Drafts can be accessed at
   http://www.ietf.org/ietf/1id-abstracts.txt.

   The list of Internet-Draft Shadow Directories can be accessed at
   http://www.ietf.org/shadow.html.

   This Internet-Draft will expire on October 15, 2008.

Copyright Notice

Abstract

   Mobile IPv6 is designed to maintain its connectivity while moving
   from one network to another. It is adopted in 3G CDMA networks as a
   way to maintain connectivity when the mobile node moves between
   access routers. However, this handover procedure requires not only
   movement detection by the MN, but also the acquisition of a new
   care-of address and Mobile IPv6 registration with the new care-of
   address before the traffic can be sent or received in the target
   network. During this period, packets destined for the mobile node
   may be lost, which may not be acceptable for real-time application
   such as Voice over IP (VoIP) or video telephony. This document
   specifies fast handover methods in the 3G CDMA networks in order to
   reduce latency and packet loss during handover.

Table of Contents

[1](#). Requirements notation

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 [[1](#)].

2. Introduction

Mobile IPv6 [2] allows mobile nodes (MNs) to maintain persistent IP
connectivity while the MN moves around in the IPv6 network. It is
adopted in 3G CDMA networks for handling host based mobility
management [11]. During handover, however, the mobile node (MN)
needs to switch the radio link, to obtain a new Care-of Address (CoA)
and to re-register with the home agent (HA), which may cause a
communication disruption. This is not desirable for real-time
applications such as VoIP and video telephony. To reduce this
disruption time or latency, a fast handover protocol for Mobile IPv6
[3] is proposed. RFC4260 [6] further describes how this Mobile IPv6
Fast Handover could be implemented on link layers conforming to the
IEEE802.11 suite of specifications. However, 3G CDMA and IEEE802.11
networks are substantially different in the radio access, the
representations of the network nodes or parameters, and the network
attachment procedures; for example, the beacon scanning or NAR
discovery based on [AP-ID, AR-info] tuples specified in RFC4260 can
not be directly applied to 3G CDMA networks. This document therefore
specifies how Mobile IPv6 fast handovers can be applied in the 3G
CDMA networks. In addition to the predictive and reactive fast
handovers defined in RFC4068, if the lower layer can provide
necessary information for handover, network-controlled fast handover
can also be applied and hence defined in this document.

3. **Terminology**

   This document refers to [3] for Mobile IPv6 fast handover
   terminology. Terms that first appear in this document are defined
   below:

   Access Network Identifier (ANID)
        An identifier that is used by the PDSN to determine whether the
        MN is being handed off from the access network that was not
        previously using this PDSN. Anytime the MN crosses into a new
        region, which is defined by the ANID, it must re-register with
        that Access Network. The ANID is further composed of the System
        ID (SID), Network ID (NID) and Packet Zone ID (PZID) and these
        values are administered by the operator. The lengths of the
        SID, NID and PZID are 2 octets, 2 octets and 1 octet,
        respectively. Thus that of the ANID occupies 5 octets [10].

   Forward Pilot Channel:
        A portion of the Forward Channel that carries the pilot. The
        Forward Channel is a portion of the physical layer channels
        transmitted from the 3G CDMA access network to the MN. Further,
        several sets of pilots (e.g. the active set or neighbor set) are
        defined to determine when and where to handover.

   Home Link Prefix (HLP):
        The prefix address assigned to the home link where the MN should
        send the binding update message. This is also called as Home
        Network Prefix (HNP) and one of the bootstrap parameters for the
        MN.

   International Mobile Subscriber Identity (IMSI):
        The IMSI is a string of decimal digits, up to a maximum of 15
        digits, that identifies a unique mobile terminal or mobile
        subscriber internationally. The IMSI consists of three fields:
        the Mobile Country Code (MCC), the Mobile Network Code (MNC),
        and the Mobile Subscriber Identification Number (MSIN). An
        example of the IMSI is "440701234567890", where "440" is the
        MCC, "70" is the MNC and "1234567890" is the MSIN. The IMSI
        conforms to the ITU-T E.212 numbering standard [5]. In this
        specification, IMSI is an ASCII string that consists of not more
        than 15 decimal digits (ASCII values between 30 and 39
        hexadecimal), one character per IMSI digit. The above example
        would therefore be encoded as "34 34 30 37 30 31 32 33 34 35 36
        37 38 39 30" in hexadecimal notation.

   Mobile Identity (MN ID)
        An Identify used by the access network to provide the Mobile
        Node Identification. The value (e.g. IMSI) is unique within
        the operator's network.

   Packet Data Serving Node (PDSN):
        An entity that routes MN originated or MN terminated packet data
        traffic. A PDSN establishes, maintains and terminates link-
        layer sessions to MNs. A PDSN is the access router in the
        visited access provider network.

   Sector Address Identifier (SectorID):
        A typical cell divides its coverage area into several sectors.
        In 3G CDMA systems, each sector uses a different PN (Pseudo
        Noise) code offset and associated with SectorID. The SectorID
        is 128-bit long and can be represented in the IPv6 address
        format [7].

4. Network reference model for Mobile IPv6 over 3G CDMA networks

   Figure 1 shows a simplified reference model of the Mobile IP enabled
   3G CDMA networks. The home agent (HA) and AAA server (AAA) of the
   mobile node (MN) reside in the home IP network and the MN roams
   within or between the access provider network(s). Usually, the home
   IP network is not populated by the MNs, which are instead connected
   only to the access provider networks. Prior to the Mobile IPv6
   registration, the MN establishes a 3G CDMA access technology specific
   link-layer connection with the access router (AR). When the MN moves
   from one AR to another, the link-layer connection is re-established
   and a Mobile IPv6 handover is performed. Those ARs reside in either
   the same or different access provider network(s). The figure shows
   the situation, where the MN moves from the previous access router
   (PAR) to the new access router (NAR) via the radio access network
   (RAN).

```
                      Home IP Network
             +........................+
             . +--------+  +--------+ .
             . |   HA   |--|  AAA   | .
             . +--------+  +--------+ .
             +../......\..............+
                /         \
            Access Provider Network(s)
      +.............+        +.............+
      . +---------+ .        . +---------+ .
      . |   PAR   | .        . |   NAR   | .
      . +---------+ .        . +---------+ .
      .      |:     .        .       :|      .
      .      |:L2link        L2link:|      .
      .      |:     .        .       :|      .
      . +----+:---+ .        . +---:+----+ .
      . |   RAN   | .        . |   RAN   | .
      . +----+:---+ .        . +---:+----+ .
      .      |:     .        .       :|      .
      .     +----+  .        .    +----+     .
      .     | MN |  --------->   | MN |     .
      .     +----+  .        .    +----+     .
      +.............+        +.............+
```
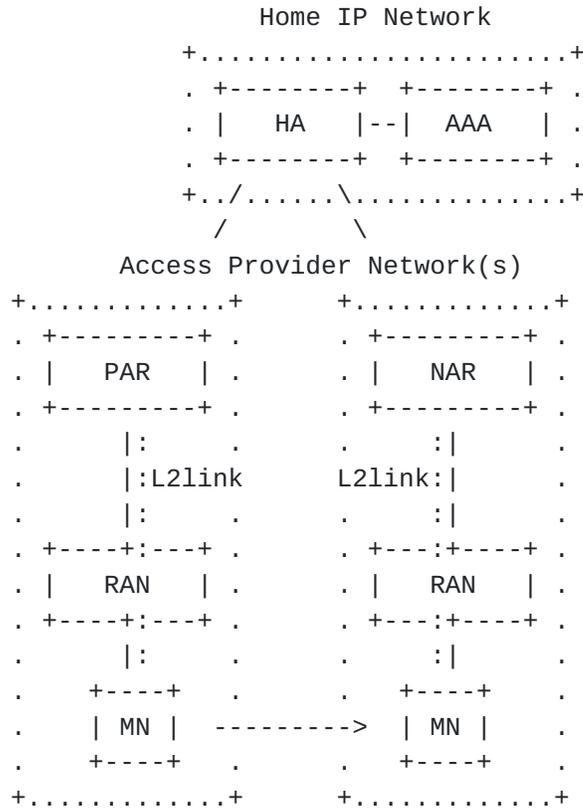
                Figure 1: Reference Model for Mobile IP

   In 3G CDMA networks, pilot channels transmitted by base stations
   allow the MN to obtain a rapid and accurate C/I (carrier to
   interference) estimate. This estimate is based on measuring the
   strength of the Forward Pilot Channel or the pilot, which is
   associated with a sector of a base station (BS). The MN searches for

the pilots and maintains those with sufficient signal strength in the
pilot sets. The MN sends measurement results, which include the
offsets of the PN code in use and the C/Is in the pilot sets, to
provide the radio access network (RAN) with the estimate of sectors
in its neighborhood. There are several triggers for the MN to send
those estimates, e.g. when the strength of a pilot in the pilot sets
exceeds that of the current pilot, the MN sends the estimates to the
access network. As long as the sector to which the MN is going to
move belongs to the same access network, the mobility within that
access network is handled by the access specific interfaces [9] and
the link-layer connection between the MN and AR can be maintained
without a reestablishment. The MN can continually search for pilots
without disrupting the data communication and a timely handover is
assisted by the network. If, however, the serving access network
finds that the sector associated with the highest pilot strength
belongs to a different AR, it attempts to close the connection with
the MN. The MN then attempts to get a new traffic channel assigned
in the new access network, which is followed by establishing a new
connection with the new AR. This could cause a noticeable
communication disruption and lead to a serious degradation of the
user experience. In order to minimize the service degradation,
during the handover between ARs, an IP-level fast handover approach
as defined in RFC4068 needs to be involved. If the air interface
information can be used as a trigger for the handover between access
routers, fast and smooth handover of Mobile IPv6 can be realized in
3G CDMA networks. The MN can continually search for pilots without
disrupting the data communication and a timely handover is assisted
by the network. If the air interface information can be used as a
trigger for the handover between access routers, fast and smooth
handover of Mobile IPv6 can be realized in 3G CDMA networks.

To assist the handover of the MN to the new AR, various types of
information can be considered: the pilot sets, which include the
candidates of the target sectors or BSs, the cell information where
the MN resides, the serving nodes in the radio access network and the
location of the MN if available. To identify the access network that
the MN moves to or from, the Access Network Identifiers (ANID) or the
subnet information can be used [8][9]. In this document, a
collection of such information is called "handover assist
information". In 3G CDMA networks, the link-layer address of the new
access point defined in [3] may not be available. If this is the
case, the MN ID option defined in this document SHOULD be used
instead.

5. Fast handover procedures

   There are two modes defined in [3] according to the time of sending
   the FBU (Fast Binding Update); one is called "predictive mode," where
   the MN sends the FBU and receives the FBAck (Fast Binding Ack) on the
   PAR (Previous Access Router)'s link and the other is called "reactive
   mode," where the MN sends the FBU from the NAR (New Access Router)'s
   link. In the predictive mode, the time and place the MN hands off
   must be indicated sufficiently before the time it actually happens.
   In cellular systems, since handovers are controlled by the network,
   the predictive mode is well applied. However, if the network is not
   configured to be able to identify the new AR, to which the MN is
   moving next, in a timely manner, the reactive mode is better applied.

   RFC4907 [19] Section 2 suggests architectural principles on the link
   indication and the effectiveness of the optimization. The link
   indication of this document relies on 3G CDMA networks and the
   effectiveness of the optimization is attributed to RFC4068bis. The
   above principles are thus considered by the related specifications
   referenced in this document.

5.1. Predictive fast handover

   Figure 2 shows the predictive mode of MIPv6 fast handover operation.
   When the MN finds a sector or a BS whose pilot signal is sufficiently
   strong, it initiates handover according to the following sequence:

   (a) A router solicitation for proxy router advertisement is sent to
        the PAR. Handover assist information for the target 3G CDMA
        network is attached to this message.

   (b) Based on the received handover assist information, the NAR is
        determined and a proxy router advertisement (PrRtAdv) containing
        the prefix of the NAR is sent back to the MN. The MN also
        checks that the R flag is not set in the PrRtAdv message, which
        indicates the network supports the predictive fast handover mode
        (defined later).

   (c) The MN creates an NCoA (new CoA) and sends the Fast Binding
        Update (FBU) with the NCoA to the PAR, which in turn sends the
        Handover Initiate (HI) to the NAR.

   (d) The NAR sends the Handover Acknowledge (HAck) back to the PAR,
        which in turn sends the FBU acknowledgment (FBAck) to the MN.

(e) The PAR starts forwarding packets toward the NCoA and the NAR
     captures and buffers them.

(f) The link-layer connection associated with the PAR is closed and
     a new traffic channel is assigned in the new access network.

(g) The MN attaches to the new access network. The attachment
     procedure is access technology specific and that for 3G CDMA
     network including the PPP transactions is described later.

(h) The MN sends the Unsolicited Neighbor Advertisement (UNA).

(i) The NAR starts delivering packets to the MN.

(j) The MN sends the BU to the HA to update the BCE with the NCoA
     and the HA sends back the BA to the MN.

```
        MN               PAR              NAR              HA              AAA
        |    RtSolPr    |                |                |                |
   (a)  |------------->|                |                |                |
        |    PrRtAdv    |                |                |                |
   (b)  |<-------------|                |                |                |
        |      FBU      |      Hl        |                |                |
   (c)  |------------->|-------------->|                |                |
        |    FBack      |     HAck       |                |                |
   (d)  |<-------------|<--------------|                |                |
        |              |forward packets|                |                |
   (e)  |              |==============>|(buffering)     |                |
        |              |                |                |                |
   (f) handover        |                |                |                |
        |              |                |                |                |
        +-------------------------------------------------------------------+
   (g) |                      Attachment procedure                          |
        +-------------------------------------------------------------------+
        |              UNA                |                |                |
   (h)  |----------------------------->|                |                |
        |         deliver packets         |                |                |
   (i)  |<=============================|                |                |
        |              |                |   BU/BA  |      |                |
   (j)  |<--------------------------------------------->|                |
        |              |                |                |                |
```
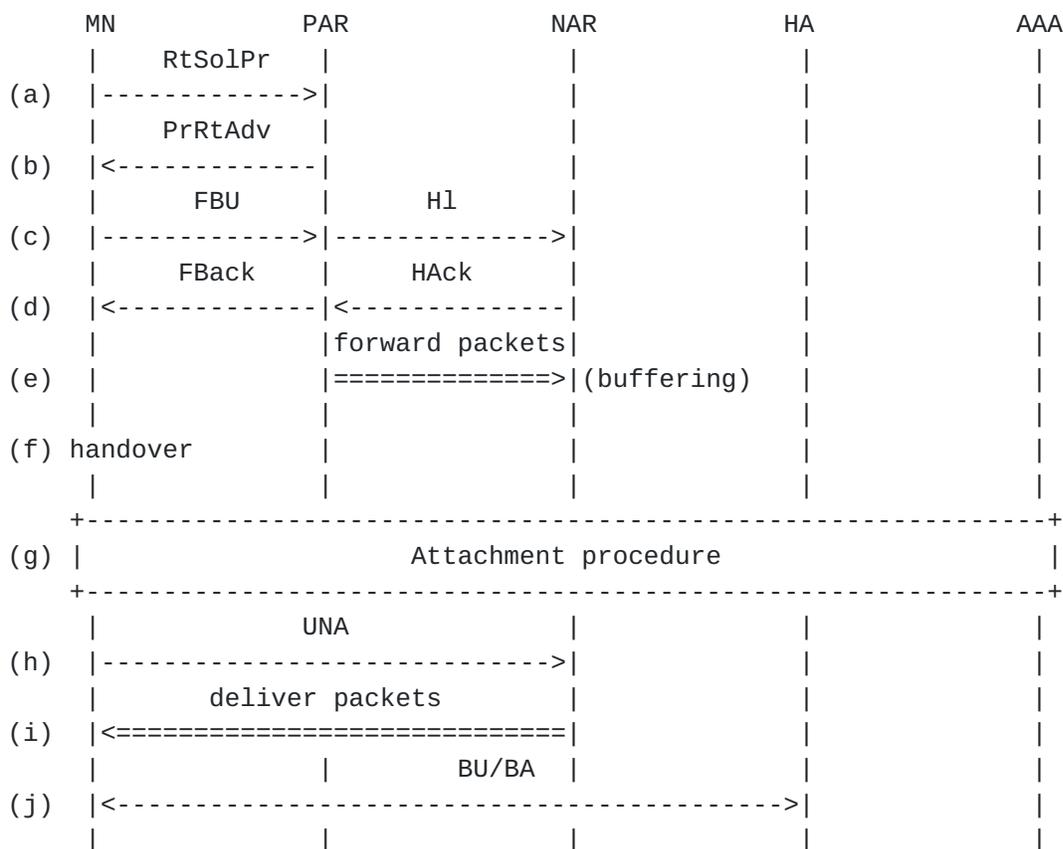
            Figure 2: MIPv6 Fast handover operation (predictive mode)

   It is assumed that the NAR can be identified by the PAR leveraging
   the handover assist information from the MN. To perform the
   predictive mode, the MN MUST send the FBU before the connection with

the current access network is closed. If the MN fails to send the
FBU before handover, it SHOULD fall back to the reactive mode. Even
if the MN successfully sends the FBU, its reception by the PAR may be
delayed for various reasons such as congestion. If the NAR receives
the HI triggered by the delayed FBU after the reception of the UNA
((c) comes after (h)), then the NAR SHOULD send the HAck with
handover not accepted and behave as the reactive mode.

In (a), RtSolPr is supposed to include the New Access Point and the
MN Link-Layer Address (LLA) options (Option Code=1 and 2,
respectively) according to [3]. The New AP-LLA option MAY be
replaced by the handover assist information option in 3G CDMA
networks. As for the MN-LLA option, if the LLA for the MN is not
available, 3G specific IDs such as IMSI[10] MAY be used. If this is
the case, the MN ID option defined in Section 6.2, which can support
other types of IDs and a length that is not necessarily multiples of
8 octets, SHOULD be used instead of the MN-LLA option.

In (b), PrRtAdv MUST include options for the IP address of the NAR,
which may be the link-local address, and the prefix for the MN. The
PAR SHOULD be able to identify the NAR from the handover assist
information provided by the MN.

Figure 3 shows the call flow for the initial attachment in the 3G
CDMA network [11]. After the traffic channel is assigned, the MN
first establishes a link-layer connection between itself and the
access router. As a link-layer protocol, PPP is considered in this
figure, and a PPP handshake is depicted as an example. After a link-
layer connection is established, the MN registers with the HA by
sending a Binding Update message. There are several parameters for
using Mobile IPv6 such as the home address (HoA), the care-of address
(CoA), the home agent address (HA) and the home link prefix (HLP).
In [11], obtaining these values is called bootstrapping, and the
bootstrapping information can be obtained during the link-layer
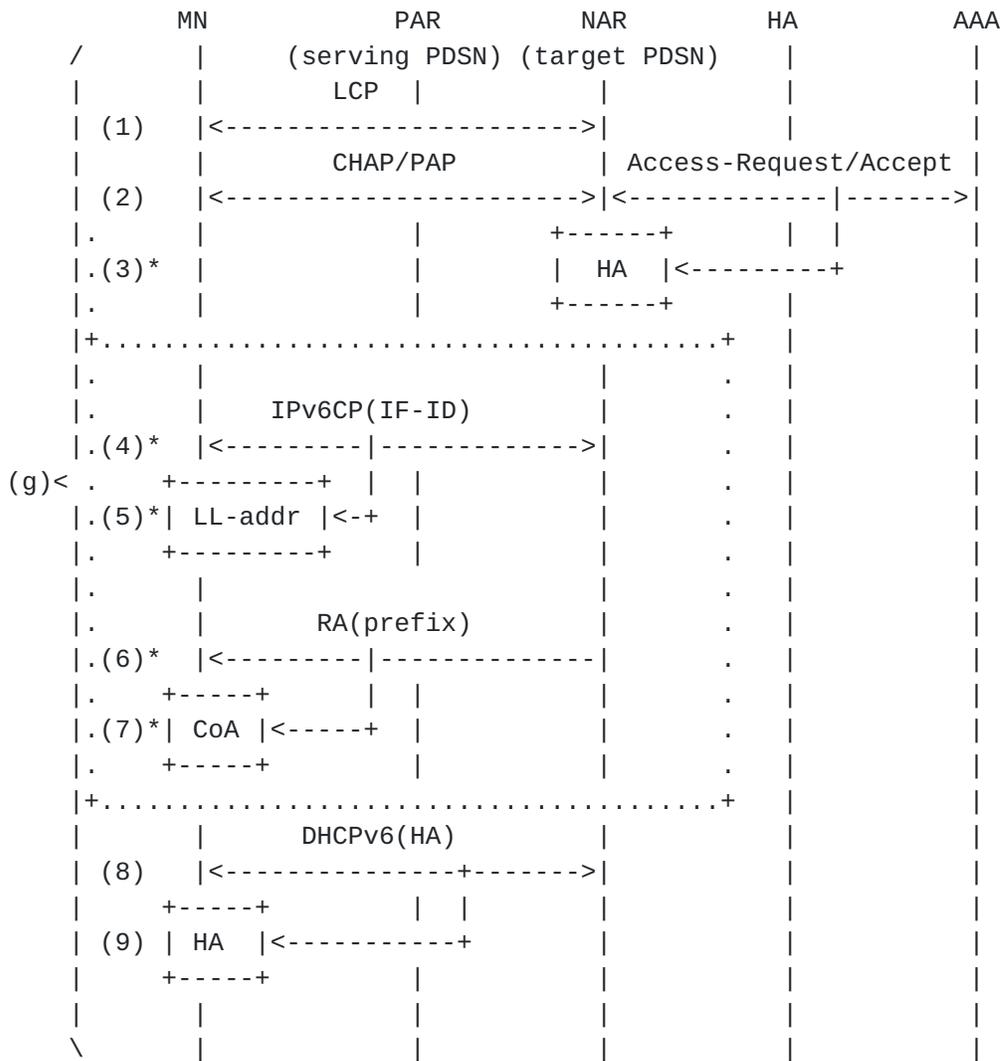establishment phase and/or the mobility binding phase [12].

```
               MN             PAR          NAR          HA          AAA
          /         |    (serving PDSN) (target PDSN)   |           |
          |         |          LCP   |           |      |           |
          | (1)     |<----------------------->|        |           |
          |         |          CHAP/PAP        | Access-Request/Accept |
          | (2)     |<----------------------->|<-------------|------->|
          |.        |              |        +------+      |  |       |
          |.(3)*    |              |        |  HA  |<---------+       |
          |.        |              |        +------+      |           |
          |+.....................................+       |           |
          |.        |              |           |    .    |           |
          |.        |      IPv6CP(IF-ID)       |    .    |           |
          |.(4)*    |<---------|------------->|      .    |           |
       (g)< .     +---------+  |  |           |      .    |           |
          |.(5)*| LL-addr |<-+  |           |      .    |           |
          |.    +---------+      |           |      .    |           |
          |.        |              |           |    .    |           |
          |.        |        RA(prefix)        |    .    |           |
          |.(6)*    |<---------|------------- |      .    |           |
          |.    +-----+       |  |           |      .    |           |
          |.(7)*| CoA |<-----+  |           |      .    |           |
          |.    +-----+          |           |      .    |           |
          |+.....................................+       |           |
          |         |       DHCPv6(HA)         |        |           |
          | (8)     |<--------------+------->|        |           |
          |     +-----+          |  |           |        |           |
          | (9) | HA  |<-----------+           |        |           |
          |     +-----+              |           |        |           |
          |         |              |           |        |           |
          \         |              |           |        |           |
```

             Figure 3: Attachment procedure in 3G CDMA network

     The procedure for the initial attachment is as follows:

     (g)   The link-layer connection establishment and the bootstrapping
              phase

     (g-1)   The LCP (Link Control Protocol) configure-request/response
              messages are exchanged.

     (g-2)   User authentication (e.g. CHAP or PAP) is conducted.

     (g-3)   The static bootstrapping information is conveyed from the AAA
              and stored in the NAR (target PDSN). The HoA and HLP can be
              dynamically assigned by the HA in the mobility binding phase.
              This step can be skipped in the handover case.

(g-4)   Unique interface IDs are negotiated in IPv6CP.

(g-5)   The MN configures its link-local address based on the obtained
        interface ID.

(g-6)   A router advertisement containing the prefix is received by
        the MN.

(g-7)   The MN configures its CoA based on the obtained prefix.

(g-8)   DHCPv6 is used to obtain the static bootstrap information
        (e.g. the HA address). This step is performed in the initial
        attachment and can be skipped once the MN obtains those
        parameters.

(g-9)   The MN installs the bootstrap information for further
        procedures (e.g. the mobility binding).

As is shown in Figure 3, it takes a considerable amount of time to
establish a link-layer connection and almost all of the above
sequences run every time the MN attaches to a new access network. It
is therefore beneficial if packets in transit to the MN are saved not
only during the time period when the MN switches to the new radio
channel but also during the time period when the MN establishes the
link-layer connection.

There are several ways to configure a unique IP address for the MN.
If a globally unique prefix is assigned per link as introduced in
[11], the MN can use any interface ID except that of the other peer
(the AR to which the MN is attached) to create a unique IP address.
If this is the case, however, the PAR cannot provide the MN with a
correct prefix for the new network in the PrRtAdv since such a prefix
is selected by the NAR and provided in the router advertisement. The
MN therefore configures a temporary NCoA with the prefix provided by
the PAR and the correct NCoA MUST be assigned by the NAR. Therefore,
in 3G CDMA network, the PAR MUST send the HI with the S flag set when
it receives the FBU from the MN at step (c) in Figure 2.

The UNA is supposed to include the MN-LLA [3], but the point-to-point
link-layer connection may be able to uniquely identify the MN. The
most required information by the UNA is the NCoA to check if there is
a corresponding buffer. In (h) therefore the function of the UNA can
be realized in several ways:

o Since the establishment of the link-layer connection in (g)
   indicates readiness of data communication on the MN side, the NAR
   immediately checks if there is a buffer that has packets destined
   for the NCoA, which was configured at steps (c) - (d), and starts

delivering if any. (substitution of UNA)

o The MN sends the UNA as defined in [3]. Instead of the MN-LLA in
   the LLA option, the MN ID MAY be included in the MN ID option.
   (standard implementation of UNA)

The primary benefit of the predictive fast handover mode is that the
packets destined for the MN can be buffered at the NAR, and packet
loss due to handover will be much lower than that of the normal MIPv6
operation. Regarding the bootstrapping, the following benefit can be
obtained, too:

o Since the NCoA can be configured via the fast handover procedures,
   a router advertisement is not required.

Therefore, the procedures (g-4) to (g-7) can be skipped from the
standard MIPv6 operation in Figure 3.

5.2. Reactive fast handover

When the networks does not support the predictive fast handover mode,
the reactive fast handover is applied. In this document, a new flag
is defined in PrRtAdv to inform the MN about the capability of the
network (see Section 6.4). To minimize packet loss in this
situation, the PAR instead of the NAR can buffer packets for the MN
until the MN regains connectivity with the NAR. The NAR obtains the
information of the PAR from the MN on the NAR's link and receives
packets buffered at the PAR. In this case, the PAR does not need to
know the IP address of the NAR or the NCoA and just waits for the NAR
to contact the PAR. However, since the PAR needs to know when to
buffer packets for the MN, the PAR obtains the timing of buffering
from the MN via the FBU or the lower layer signaling, e.g. an
indication of the release of the connection with the MN. Details of
the procedure are as follows:

(a) A router solicitation for proxy router advertisement MAY be sent
     to the PAR.

(b) The proxy router advertisement MAY be sent to the MN, but the
     prefix of the NAR is (or is not) included.

(c) The MN sends the FBU or the access network indicates the close
     of the connection with the MN by the lower layer signaling. If
     the B flag is set in the FBU, the PAR SHOULD start buffering
     packets destined for the PCoA.

(d) The link-layer connection associated with the PAR is closed and
     a new traffic channel is assigned in the new access network.

(e) The MN attaches to the new access network. This part is the
     same as described in Section 5.1 and illustrated in Figure 3.

(f) The MN sends the UNA to the NAR.

(g) The MN sends the Fast Binding Update (FBU) to the PAR via the
     NAR.

(h) The NAR forwards the FBU from the MN to the PAR.

(i) The PAR sends the Handover Initiate (HI) to the NAR with the
     Code set to 1.

(j) The NAR sends the Handover Acknowledge (HAck) back to the PAR.

(k) The PAR sends the FBAck to the NAR.

(l) If the PAR is buffering packets destined for the PCoA, it starts
     forwarding them as well as newly arriving ones to the NAR.

(m) The NAR delivers the packets to the MN.

(n) The MN sends the BU to the HA to update the BCE with the NCoA
     and the HA sends back the BA to the MN.

```
              MN            PAR           NAR            HA           AAA
               |   RtSolPr   |             |             |             |
     (a)       |------------>|             |             |             |
               |   PrRtAdv   |             |             |             |
     (b)       |<------------|             |             |             |
               |      FBU    |             |             |             |
     (c)       |- - - - - ->|(buffering)   |             |             |
               |             |             |             |             |
     (d) handover            |             |             |             |
               |             |             |             |             |
          +-------------------------------------------------------------+
     (e)  |                    Attachment procedure                     |
          +-------------------------------------------------------------+
               |            UNA            |             |             |
     (f)       |-------------------------->|             |             |
               |            FBU            |             |             |
     (g)       |-------------------------->|             |             |
               |             |     FBU     |             |             |
     (h)       |             |<------------|             |             |
               |             |      HI     |             |             |
     (i)       |             |------------>|             |             |
               |             |     HAck    |             |             |
     (j)       |             |<------------|             |             |
               |             |    FBack    |             |             |
     (k)       |             |------------>|             |             |
               |             |forward packets|           |             |
     (l)       |             |=============>|             |             |
               |        deliver packets    |             |             |
     (m)       |<==========================|             |             |
               |             |    BU/BA    |             |             |
     (n)       |<----------------------------------------->|           |
               |             |             |             |             |
```
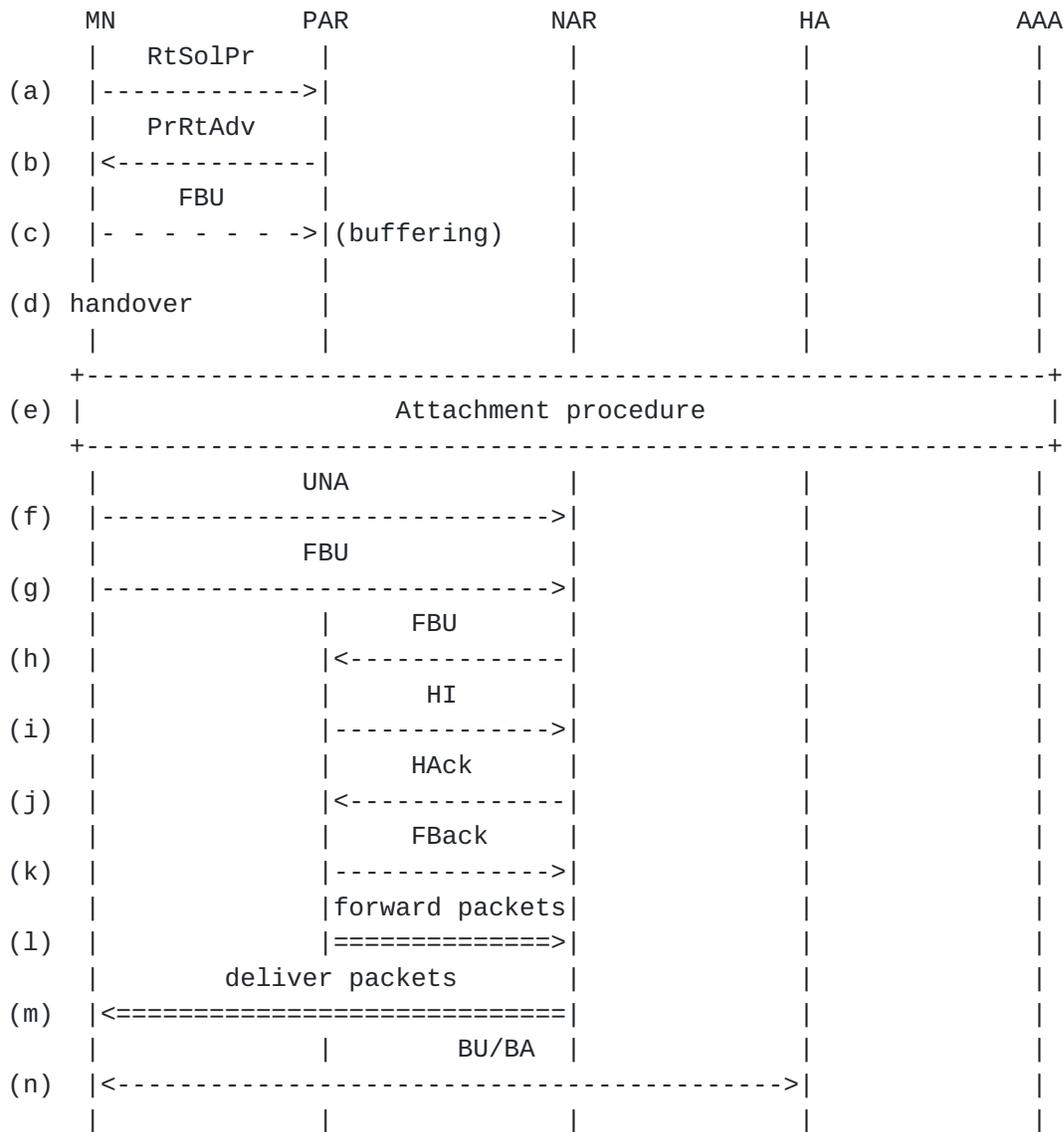
                Figure 4: MIPv6 Fast handover operation (reactive mode)

   To indicate the PAR to buffer packets destined for the PCoA, in step
   (c), a new flag 'B' is defined in the FBU. When the PAR receives the
   FBU with this flag set, it SHOULD buffer packets for the MN. The PAR
   MAY also start buffering packets for the MN based on lower layer
   signal during handover. Since the packets are buffered at the PAR in
   this scenario, the UNA, which is received and processed by the NAR,
   can not be used to trigger to forward the buffered packets at the
   PAR. In Figure 4, the HAck from the NAR is used as the trigger for
   the forwarding of any buffered packets.

   The handover indication from the lower layer of 3G CDMA system is
   reasonably reliable by the periodical reports from the MN; however,
   there are several situations where the target link is not available

after the handover (step (d)) and the MN comes back to the PAR, or
the MN is not able to move to the target link for some reason after
the connection was closed. If this is the case, the attachment
procedure is performed on the previous link. The packets buffered at
the PAR SHOULD be delivered to the MN after the connection is re-
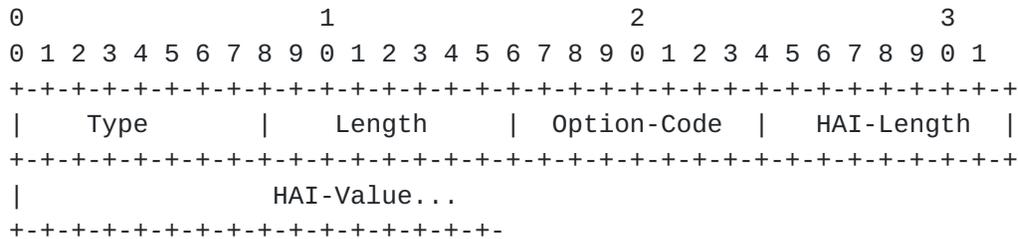established.

5.3. Considerations on the link indications

This section discusses if the link indications assumed in this
document meet the principles defined in RFC4907[19] Section 2, which
suggests 11 architectural principles on the link indication and the
effectiveness of the optimization. This document relies on the 3G
CDMA network regarding the link indication, which is precisely
specified by 3GPP2. Therefore, principles (1) to (5), (7), (8) and
(11), that is, "Model Validation", "Clear Definition", "Robustness",
"Recovery from Invalid Indications", "Congestion Control",
"Interoperability", "Race Condition" and "Transport of Link
Indications" are considered by those specs. Principle (6)
"Effectiveness" mentions the effectiveness of the optimization. This
document bases its effectiveness on RFC4068bis. Therefore this
principle is dealt by that RFC. Principle (9) "Metric Consistency"
mentions inconsistencies between link and routing layer metrics. The
spec of this document does not change the routing metrics and multi-
homing is not considered. Finally, principle (10) "Layer
Compression", mentions overhead reduction scheme and
interoperability. This document does not deal with overhead
reduction and therefore this principle does not apply.

6. Message Format

6.1. Handover Assist Information Option

   If the lower layer information of the new point of attachment is not
   represented as the Link-Layer Address, the following option SHOULD be
   used. The primary purpose of this option is to convey the handover
   assist information described in Section 4.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Type       |     Length    |  Option-Code  |   HAI-Length  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              HAI-Value...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
```

   Type   TBD1

   Length   The size of this option in 8 octets including the
                   Type, Length, Option-Code and AS-Length fields.

   Option-Code
                   1: Access Network Identifier (AN ID)
                   2: Sector ID

   HAI-Length   The size of the HAI-Value field in octets.

   HAI-Value   The value specified by the Option-Code.

   If those which received this message do not support this option, they
   SHOULD treat this option as opaque and MUST NOT drop it.

   Option-Code Indicates the particular type of handover assist
   information. Currently, two types of information are defined to
   assist the discovery of the NAR (See Section 3).

   Depending on the size of the HAI-Value field, appropriate padding
   MUST be used to ensure that the entire option size is a multiple of 8
   octets. The HAI-Length is used to disambiguate the size of the HAI-
   Value.

   The handover assist information MAY replace the New Access Point
   Link-Layer Address in 3G CDMA networks.

6.2. MN ID Option

   This option is used to transfer the Identifier of the MN, which is
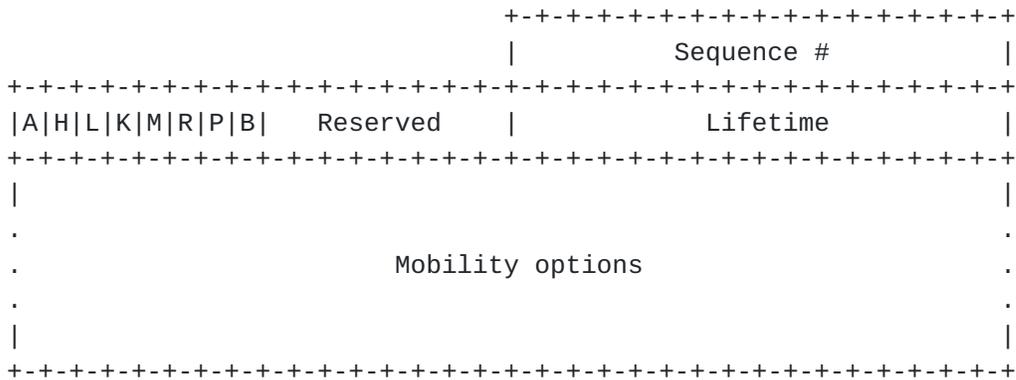   not its link-layer address.

```
 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
+---------------+---------------+---------------+---------------+
|     Type      |     Length    |  Option-Code  |  MN ID-Length |
+---------------------------------------------------------------+
|              MN ID ...
+----------------------------
```
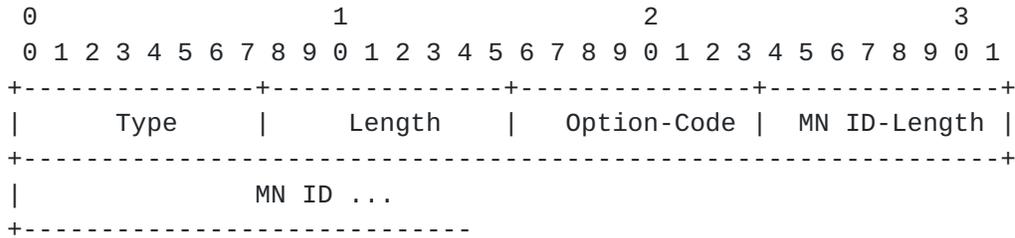
   Type   TBD2

   Length   The size of this option is in 8 octets including the
                 Type, Length and Option-Code.

   Option-Code

                 1: NAI [4]
                 2: IMSI (See Section 3)

   MN ID-Length The length of the MN ID in octets.

   MN ID   MN ID value

   The MN ID MAY replace the MN Link-Layer Address in 3G CDMA networks.

6.3. New flag extension to FBU message

   The MN MUST send the FBU to the PAR with the following new (B) flag
   set in the previous network to indicate the PAR to buffer packets
   destined for the PCoA. The rest of the Binding Update message format
   remains the same as defined in [2] and with the additional (M), (R)
   and (P) flags as specified in [13], [14] and [15], respectively.

```
                        +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        |          Sequence #           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |A|H|L|K|M|R|P|B|    Reserved   |            Lifetime           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                                               |
   .                                                               .
   .                     Mobility options                         .
   .                                                               .
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   B flag: If the 'B' flag is set, the PAR SHOULD start buffering
                   the packets destined for the MN as specified in
                   Section 5.2.

6.4. New flag extension to PrRtAdv message

   A new flag 'R' is defined in the PrRtAdv to inform the MN about the
   fast handover mode that the network supports.

```
    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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |     Type      |     Code      |            Checksum           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |    Subtype    |R|  Reserved   |             Identifier        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |    Options ...
   +-+-+-+-+-+-+-+-+-+-+-
```
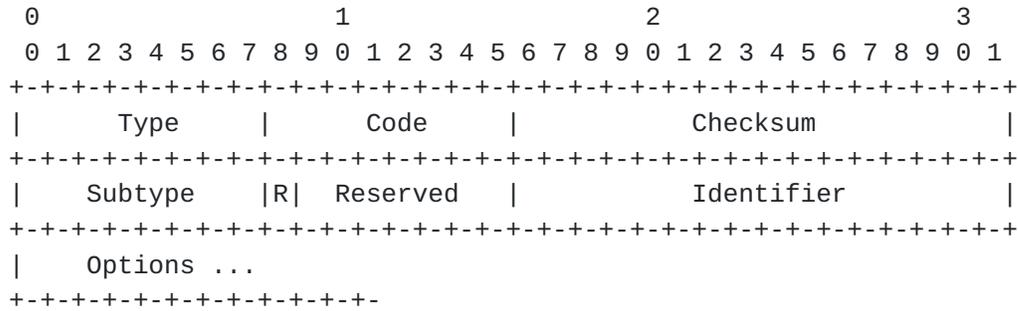
   R flag: If the 'R' flag is set, the network supports only the
                   reactive handover mode. Otherwise, the network
                   supports both the predictive and reactive fast
                   handover mode.

7. **Security Considerations**

   The security considerations for Mobile IPv6 fast handover are
   described in [3]. When a 3G CDMA network is considered, it can be
   assumed that the PAR and the NAR have a trust relationship and the
   links between them and those between the ARs and the MN are secured.
   The MN is authenticated every time it attaches to the new link;
   therefore the AR can securely identify the MN. Depending on the
   operator's policy, however, SEND [17] and the shared handover key
   defined in [16] can also be applied.

8. IANA Considerations

   This document defines two new IPv6 Neighbor Discovery options that
   need to be assigned from the same space as the IPv6 Neighbor
   Discovery Options defined in [18]

      TBD1: Handover Assist Information Option (Section 6.1)

      TBD2: MN ID option (Section 6.2)

   This document requires two new registries to be created for the
   Option-Code field in the Handover Assist Information Option and that
   in the Mobile Node Identifier Option. The values for the Option-Code
   must be within the range 0-255. New values for both registries can
   be allocated by Standards Action or IESG approval.

   The Option-Code values that need to be assigned by IANA are as
   follows:

    Option-Code for Handover Assist Information Option
    Value Description   Reference
    ----- ---------------------------- ----------
      0   Reserved
      1   ANID   Section 6.1
      2   Sector ID   Section 6.1

    Option-Code for Mobile Node Identifier Option
    Value Description   Reference
    ----- ---------------------------- ----------
      0   Reserved
      1   NAI   Section 6.2
      2   IMSI   Section 6.2

9. Acknowledgements

The authors would like to thank Kuntal Chowdhury, Ashutosh Dutta, Ved
Kafle and Vijay Devarapalli for providing feedback and support for
this work. The authors would also thank Sebastian Thalanany for
3GPP2 expert review.

10. References

10.1. Normative References

[1]   Bradner, S., "Key words for use in RFCs to Indicate Requirement
       Levels", BCP 14, RFC 2119, March 1997.

[2]   Johnson, D., "Mobility Support in IPv6", RFC 3775, June 2004.

[3]   Koodli, R., Ed., "Mobile IPv6 Fast Handovers",
        draft-ietf-mipshop-fmipv6-rfc4068bis-06.txt, February 2008.

[4]   Aboba, B., Beadles, M., Arkko, J., and P. Eronen, "The Network
       Access Identifier", RFC 4282, December 2005.

[5]   ITU-T Recommendation, "The international identification plan
       for mobile terminals and mobile users", ITU-T E.212, May 2004.

10.2. Informative References

[6]   McCann, P., "Mobile IPv6 Fast Handovers for 802.11 Networks",
       RFC 4260, November 2005.

[7]   3GPP2 TSG-C, "cdma2000 High Rate Packet Data Air Interface
       Specification", C.S0024-A v.2.0, July 2005.

[8]   3GPP2 TSG-A, "3GPP2 Access Network Interfaces Interoperability
       Specification", A.S0001-A v.2.0, June 2001.

[9]   3GPP2 TSG-A, "Interoperability Specification for High Rate
       Packet 1 2 Data (HRPD) Access Network Interfaces - Rev A.",
       A.S0007-A v.2.0, May 2003.

[10]   3GPP2 TSG-A, "Interoperability Specification (IOS) for High
       Rate Packet Data (HRPD) Access Network Interfaces", 3GPP2
       A.S0008-0 v3.0, May 2003.

[11]   3GPP2 TSG-X, "cdma2000 Wireless IP Network Standard: Simple IP
       and Mobile IP services", X.S0011-002-D v.1.0, February 2006.

[12]   Devarapalli, V., Patel, A., Keung, K., and K. Chowdhury,
       "Mobile IPv6 Bootstrapping for the Authentication Option
       Protocol",
        draft-devarapalli-mip6-authprotocol-bootstrap-03.txt,
       September 2007.

[13]   Soliman, H., Castelluccia, C., El Malki, K., and L. Bellier,
       "Hierarchical Mobile IPv6 Mobility Management (HMIPv6)",

          RFC 4140, August 2005.

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

   [15]   Gundavell, S., Ed., Leung, K., Devarapalli, V., Chowdhury, K.,
          and B. Patil, "Proxy Mobile IPv6",
           draft-ietf-netlmm-proxymip6-10.txt, February 2008.

   [16]   Kempf, J., Ed. and R. Koodli, "Distributing a Symmetric FMIPv6
          Handover Key using SEND",
           draft-ietf-mipshop-handover-key-03.txt, November 2007.

   [17]   Arkko, J., Kempf, J., Zill, B., and P. Nikander, "SEcure
          Neighbor Discovery (SEND)", RFC 3971, March 2005.

   [18]   Narten, T., Nordmark, E., Simpson, W., and H. Soliman,
          "Neighbor Discovery for IP version 6 (IPv6)", RFC 4861,
          September 2007.

   [19]   Aboba, B., "Architectural Implications of Link Indications",
          RFC 4907, June 2007.

Authors' Addresses

    Hidetoshi Yokota
    KDDI Lab
    2-1-15 Ohara, Fujimino
    Saitama, 356-8502
    JP

    Phone: +81 49 278 7894
    Fax: +81 49 278 7510
    Email: yokota@kddilabs.jp

    Gopal Dommety
    Cisco Systems, Inc.
    170 West Tasman Drive
    San Jose, CA 95134
    US

    Phone: +1 408 525 1404
    Email: gdommety@cisco.com