Mobile IP Working Group   Milind Kulkarni
INTERNET-DRAFT   Alpesh Patel
Category: Standards Track   Kent Leung
Date   : 12 December 2005   Cisco Systems Inc.

                   Mobile IPv4 Dynamic Home Agent Assignment
                   draft-ietf-mip4-dynamic-assignment-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 June 12, 2006.

Copyright Notice

Abstract

   Mobile IPv4 [1] uses the Home Agent (HA) to anchor sessions of a
   roaming Mobile Node (MN). This draft proposes a messaging mechanism
   for dynamic home agent assignment and HA redirection. The goal is to
   provide a mechanism to assign an optimal HA for a Mobile IP session
   while allowing any suitable method for HA selection.

Table of Contents

1. Introduction

This document adds to the Mobile IP protocol [1], by proposing a
messaging mechanism for dynamic home agent assignment and home agent
redirection during initial registration. The goal is to assign an
optimal HA for a Mobile IP session.   The mobile node MUST use the
Network Access Identifier (NAI) extension [2] when requesting a
dynamically assigned HA.

The MN requests a dynamically assigned HA by setting the HA field in
the initial Registration Request to ALL-ZERO-ONE-ADDR (defined in
section 2). If the request is accepted, the HA sends a successful
Registration Reply containing the HA's own address. The requested HA
can suggest an alternate HA and if so, the Registration Reply is
rejected with a new error code REDIRECT-HA-REQ and the alternate HA
address is specified in a new extension (Redirected HA Extension).

This document also defines a new Requested HA Extension for use in
Registration Requests when the HA field is set to ALL-ZERO-ONE-
ADDRESS. The Requested HA address is a hint to the network about the
MN's preferred HA.

The messaging mechanism is defined in this document so that the
MN can request and receive a dynamic HA address in Mobile IP
messages. However, the mechanism by which the network selects
an HA for assignment to the MN is outside the scope of this
document. For example, the selection may be made by any
network node that receives the registration request (or
information about the registration request), such as a Foreign
Agent, AAA server, or Home Agent.   The node that selects the
HA may select one based on a number of criteria, including but
not limited to HA load-balancing, geographical proximity,
administrative policy etc.

2. Requirements Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
"SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this
document are to be interpreted as described in RFC 2119 [6].

The Mobile IP related terminology described in RFC 3344 [1] is used
in this document.   In addition, the following terms are used:

ALL-ZERO-ONE-ADDR: IP address 0.0.0.0 or 255.255.255.255. An
                   address of 255.255.255.255 indicates a preference
                   for an HA in the home domain. An address of
                   0.0.0.0 indicates no preference for home vs.
                   visited domain.

   Requested HA: Destination IP address of Home Agent that the
                      Registration Request is sent to. Must be a
                      unicast IP address. This address can be
                      obtained as described in section 6.

                      Note that this specification defines a new
                      "Requested HA Extension" in section 3.4, which
                      is different from the term "Requested HA".

   Assigned HA: The HA that accepts an MN's Registration Request
                      and returns a successful Registration Reply.

   Redirected HA: If the registration is rejected with error code
                      REDIRECT-HA-REQ, the HA being referred to is
                      specified in a new extension (Redirected HA
                      Extension).

   AAA server: Authentication, Authorization and Accounting
                      Server.

   DNS: Domain Name System.

   DHCP: Dynamic Host Configuration Protocol.

   MN: Mobile Node as defined in Mobile IPv4 [1].

   HA: Home Agent as defined in Mobile IPv4 [1].

   FA: Foreign Agent as defined in Mobile IPv4 [1].

   CoA: Care of Address.

   CCoA: Co-located Care of Address.

   MN HoA: Mobile Node's Home Address.

   NAI: Network Access Identifier [2].

   Src IP: Source IP address of the packet.

   Dest IP: Destination IP address of the packet.

   RRQ: Registration Request.

3. Problem Statement

   The Mobile IPv4 NAI Extension for IPv4 [2] introduced the concept of
   identifying a MN by the NAI and enabling dynamic home address

assignment. When the home address is dynamically assigned, it is

desirable to discover the Home Agent dynamically or inform the MN
about an optimal HA to use for a multitude of reasons, such as:

- If the distance between the visited network and the home network of
the mobile node is large, the signaling delay for these registrations
may be long. In such a case the MN will be anchored to its distant
home agent, resulting in tunneled traffic traveling a long distance
between home agent and the mobile node. When a Mobile IP session
initiates, if the mobile node can be assigned a home agent that is
close to the mobile node it can drastically reduce the latency
between the home agent and mobile node.

- In a large scale Mobile IP deployment, it is cumbersome to
provision MNs with multiple HA addresses.

- It is desirable to achieve some form of load balancing between
multiple HAs in the network. Dynamic HA assignment and/or HA
redirection lets the network select the optimal HA from among a set
of HAs and thus achieve load balancing among a group of HAs.

- Local administrative policies.

3.1 Scope

This specification does not address the problem of distributing a
security association between the MN and HA, and it can either be
statically preconfigured or dynamically distributed using other
mechanisms [7].

The draft introduces the terms Requested/Assigned/Redirected HA
(section 6). The discovery of candidate HA addresses for insertion
into the Redirected HA Extension can be accomplished through various
means which are network and/or deployment specific and hence are
outside the scope of this specification.

The MN MAY request dynamic HA assignment when it is not aware of any
HA address and even when it is aware of at least one HA address.

3.2 Dynamic Home Agent Discovery in Mobile IPv4

Mobile IPv4 [1] specifies the mechanism for discovering the mobile
node's home agent using subnet-directed broadcast IP address in the
home agent field of the Registration Request.   This mechanism was
designed for mobile nodes with a static home address and subnet
prefix, anchored on fixed home network.   However, using subnet
directed broadcast as the destination IP address of the Registration

Request, it is unlikely that the Registration Request will reach the home subnet because routers will drop these packets by default. See CERT Advisory CA-1998-01 Smurf IP Denial-of-Service Attacks [3].

3.3 NAI usage and dynamic HA assignment

The Mobile IPv4 NAI Extension for IPv4 [2] introduced the
concept of identifying a MN by the NAI and enabling dynamic
home address assignment. This document requires that while
using dynamic HA assignment, MN MUST use the NAI and obtain a home
address. MN can still suggest a static home address in the
Registration Request, but must take the address in the Registration
Reply as the home address for the session. This is compatible with
the procedures documented in the NAI specification [2].

3.4 Dynamic HA Extension

The Dynamic HA Extension, shown in figure 1, contains the address of
the HA. This is a generic extension and can be used in Registration
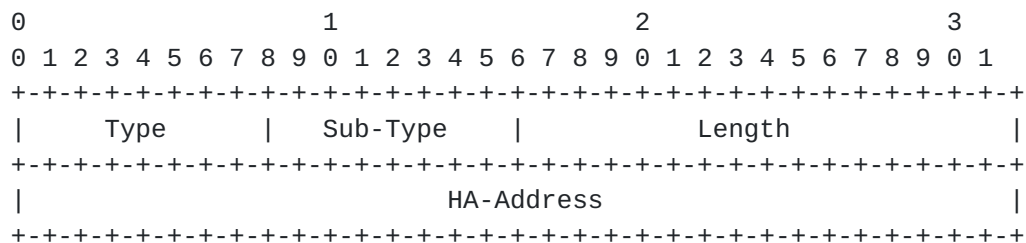Request and Reply messages. It is a skippable extension.

```
 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      |   Sub-Type    |            Length             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        HA-Address                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 1: The Dynamic HA address Extension

> Type   DYNAMIC-HA-ADDRESS (skippable) (to be assigned by
>   IANA) is the type, which specifies the dynamic HA
>   address.
>
> Sub-Type   Defines the use of this extension as:
>   sub-type 1 = Requested HA Extension
>   2 = Redirected HA Extension
>
> Length   Indicates the length of the extension not
>   including the type, sub-type and length fields.
>   Length is always 4 bytes.
>
> HA-Address   Address of the Home Agent.

3.4.1 Requested HA Extension

The Requested HA Extension is a Dynamic HA Extension of subtype 1.

The MN may include the Requested HA Extension in the registration
request as a hint to the network where it wishes to be anchored.

This extension contains the address of the HA. A valid unicast IP address MUST be used as HA address in this extension.

In absence of an FA, the Registration Request is forwarded to this HA. In presence of an FA, the FA MUST forward Registration Request to the HA address in this extension.

3.4.2 **Redirected HA Extension**

The Redirected HA Extension is a Dynamic HA Extension of subtype 2.

The Redirected HA Extension contains the address of the HA where the MN should attempt the next registration. The HA receiving a Registration Request can suggest an alternate HA and, if so, the Registration Reply is sent with a new error code REDIRECT-HA-REQ and the alternate HA address is specified in this extension.

The Redirected HA Extension MUST be included in Registration Reply when the reply code is REDIRECT-HA-REQ.

4. **Messaging mechanism for dynamic HA assignment/redirection**

This specification presents two alternatives for home agent assignment. The two alternatives are:
(a) Dynamic HA assignment (described in section 4.1) and
(b) HA redirection (described in section 4.2).

4.1 **Messaging for dynamic HA assignment**

The following sequence of events occurs when the MN requests dynamic Home Agent assignment:

1. The MN sets the Home Agent address field in the Registration Request to ALL-ZERO-ONE-ADDR. If the MN is aware of a desired HA address, it can add that address in the Requested HA Extension in the Registration Request. If the HA does not support the Requested HA Extension, see step 2 below.

2. This step is applicable, in lieu of step 1, for a MN that is aware of the HA address and desires dynamic HA assignment. Also, the MN follows this (when aware of a HA address) when it discovers a legacy FA in the path or if the known HA does not support the Requested HA Extension (see section 10).

   The MN sets the Home Agent address field in the Registration Request to the HA address (instead of setting it to ALL-ZERO-ONE-ADDR). The MN also adds the same HA address in the Requested HA

Extension in the Registration Request.

   3. The MN (if using co-located CoA and registering directly with the
      HA) or the FA (if the MN is registering via the FA) sends the
      Registration Request to the "Requested HA". If the Requested HA
      Extension is present, Requested HA is specified in the "HA
      Address" of this extension.
      Per section 10, in case of a legacy FA, legacy FA forwards the
      Registration Request to the address in the HA field of the
      Request (thus, MN uses step 2 above in case of legacy FA instead
      of step 1).

   4. The "Requested HA" is the home agent that processes the
      Registration Request in accordance with Mobile IPv4 [1] and as
      per the specification in this document. It creates mobility
      binding for successful Registration Request. It also sends a
      Registration Reply to the MN.

   5. The MN obtains an "Assigned HA" address from the HA field in the
      successful Registration Reply and uses it for the remainder of
      the session. (Note that the "Assigned HA" will be same as the
      "Requested HA").

   6. Subsequent Registration Request messages for renewal are sent to
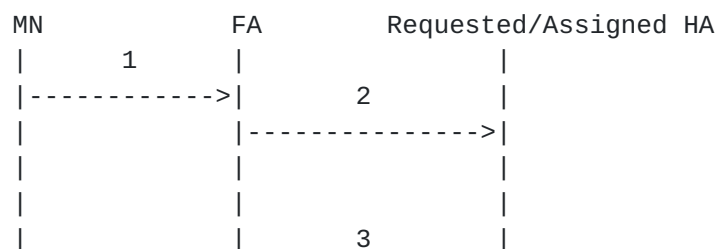   the Assigned HA.

   Section 5.3.1 describes the Assigned HA in detail. Some ideas on how
   to select the Requested HA are briefly covered in section 6.

4.1.1 **Example with Message Flow Diagram**

   Detailed explanation of this alternative is best described with the
   help of a message flow diagram and description.

   Figure 2 shows one specific example of a Mobile Node using an FA-
   located Care of Address (FA CoA) and FA understands the Requested HA
   Extension per this specification.

   Other scenarios such as when the mobile node uses a co-located care
   of address and presence of a legacy HA or FA are not described below,
   but the behavior is similar.

```
              MN              FA          Requested/Assigned HA
              |       1       |                    |
              |------------->|         2          |
              |              |--------------->|
              |              |                    |
              |              |                    |
              |              |         3          |
```

```
            |      4      |<---------------|
            |<------------|                |
            |             |                |
```

```
           |               |       5       |
           |------------------------------>|
           |               |               |
```

     Figure 2: Example message flow for dynamic HA assignment

1. The MN sets the Home Agent address field in the Registration
Request to ALL-ZERO-ONE-ADDR. Since the MN is using FA CoA in this
example, it sends the Registration Request to the FA. The
Registration Request is formatted as follows:

```
+--------------------------------------------------------------+
| Src IP=| Dest IP =  | MN HoA  |    HA Address =   | CoA = |
|  MN    |    FA      |         | ALL-ZERO-ONE-ADDR |FA CoA |
+--------------------------------------------------------------+
```

If the MN is aware of a desired HA address, it can add that address
in the Requested HA Extension in Registration Request as a hint.
That extension is not shown above.

2. The FA sends the Registration Request to the Requested HA. If
Requested HA Extension is present, Requested HA is the HA address in
this extension. If the Requested HA Extension is not present, the FA
determines the Requested HA through means outside the scope of this
specification. The Registration Request is formatted as follows:

```
+--------------------------------------------------------------+
| Src IP=| Dest IP =  | MN HoA  |    HA Address =   | CoA = |
|  FA    |Requested HA|         | ALL-ZERO-ONE-ADDR |FA CoA |
+--------------------------------------------------------------+
```

(If MN includes the Requested HA Extension, the FA copies that
extension. The FA then forwards the Registration Request, along with
the Requested HA Extension, to the HA address specified in Requested
HA Extension.)

3. The HA processes the Registration Request in accordance with
Mobile IPv4 [1] and the messaging defined in this document. The HA
creates mobility binding for successful request and becomes the
Assigned HA. The HA then sends Registration Reply to the FA, which
is formatted as follows:

```
+--------------------------------------------------------------+
| Src IP=| Dest IP =  | MN HoA  |    HA Address =   | CoA = |
|Assigned| Src IP of  |         |    Assigned HA    |FA CoA/|
|  HA    | the RRQ    |         |                   |       |
+--------------------------------------------------------------+
```

4. The FA relays the Registration Reply to the MN, as follows.

```
+----------------------------------------------------------+
| Src IP=| Dest IP = | MN HoA  |    HA Address =  | CoA = |
|  FA    |    MN     |         |    Assigned HA   |FA CoA/|
+----------------------------------------------------------+
```

5. The MN obtains the Assigned HA address from the HA field in the
successful Registration Reply and uses it for the remainder of the
session. The MN sends subsequent Re-Registration or De-Registration
Requests for the remainder session directly to the Assigned HA. The
Home Agent address field in this Registration Request is set to
ALL-ZERO-ONE-ADDR. Note that the Assigned HA is the same as the
Requested HA.

4.2 Messaging for HA redirection

This section describes the events that occur when the Requested HA
does not accept the Registration Request and redirects the mobile
node to another HA (aka Redirected HA) instead. This behavior is not
exhibited by a legacy HA and so is not referred in the description
below. In presence of a legacy FA, please refer to section 4.1 for
the specific field in the Registration Request.

1. The MN sets the Home Agent address field in the Registration
   Request to ALL-ZERO-ONE-ADDR.

2. The MN (if using co-located CoA and registering directly with the
   HA) or FA (if the MN is registering via the FA) sends the
   Registration Request to the "Requested HA". If the MN is aware of
   an HA address, it can add that address in the Requested HA
   Extension in Registration Request.

3. When the HA receives the Registration Request, if the HA field is
   set to ALL-ZERO-ONE-ADDR, the HA may reject the request with Reply
   code REDIRECT-HA-REQ and suggest an alternate HA.

   The HA may reject the Request for a number of reasons, which are
   outside the scope of this specification. If the HA rejects the
   Request, the HA field in the Reply is set to this HAs address.
   The IP address of the HA that is the target of the redirection is
   specified in Redirected HA Extension. The presence of this
   extension is mandatory when the reply code is set to REDIRECT-HA-
   REQ. HA sends the Reply to the FA/MN.

4. FA sends the Reply to the MN.

5. If the error code is set to REDIRECT-HA-REQ, MN obtains the HA
   address from Redirected HA Extension. The MN then sends a

Registration Request to Redirected HA. The MN may choose to add
Requested HA extension in this new Registration Request. If a
registration loop occurs (the case when the Redirected HA is an HA

that had already directed the MN to register elsewhere) then the
MN stops sending any further Registration Request and provides an
indication that the loop event was detected. The number of
consecutive Redirected HAs remembered by MN for loop detection is
an implementation parameter.

[4.2.1](#) **Example with Message Flow Diagram**

Figure 3 shows one specific example of a Mobile Node using FA-located
Care of Address, where the FA is not a legacy FA.

```
   MN              FA           Requested HA     Redirected HA
   |        1       |               |                |
   |-------------->|        2       |                |
   |               |--------------->|                |
   |               |                |                |
   |               |                |                |
   |               |        3       |                |
   |        4       |<---------------|                |
   |<-------------|                |                |
   |               |                |                |
   |               |        5       |                |
   |----------------------------------------------->|
   |               |                |                |
```
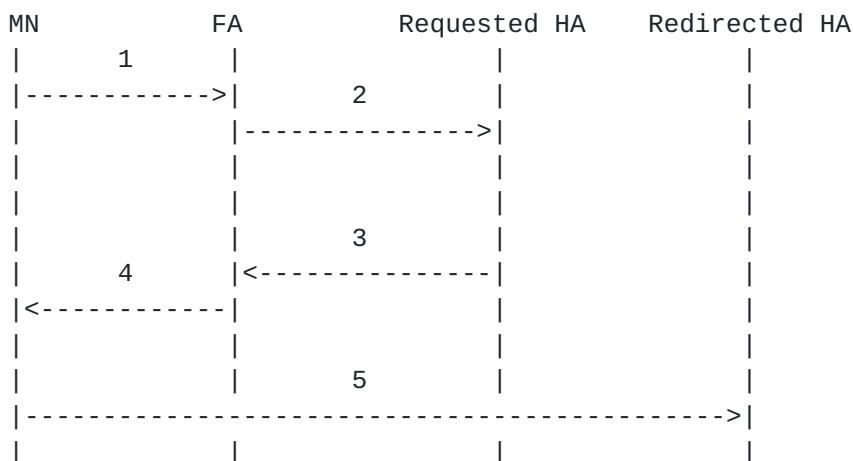
Figure 3: Example message flow for HA redirection

1. The MN sets the Home Agent address field in the Registration
Request to ALL-ZERO-ONE-ADDR. Since the MN is using FA CoA in this
example, it sends the Registration Request to the FA. The
Registration Request is formatted as follows:

```
+--------------------------------------------------------------+
| Src IP=| Dest IP =  | MN HoA  |     HA Address =   | CoA = |
|  MN    |    FA      |         | ALL-ZERO-ONE-ADDR  |FA CoA |
+--------------------------------------------------------------+
```

If the MN is aware of an HA address, it can add that address in the
Requested HA Extension in Registration Request as a hint. That
extension is not shown above.

2. The FA sends the Registration Request to the Requested HA. If
Requested HA Extension is present, Requested HA is the HA address in
this extension. If the Requested HA Extension is not present, the FA

determines the Requested HA through means outside the scope of this
specification. The Registration Request is formatted as follows:

```
+-------------------------------------------------------------+
| Src IP=| Dest IP =  | MN HoA  |   HA Address =   | CoA = |
|   FA    |Requested HA|         | ALL-ZERO-ONE-ADDR |FA CoA |
+-------------------------------------------------------------+
```

3.   The HA processes the Registration Request in accordance with
Mobile IPv4 [1] and the messaging defined in this specification. If
the registration is successful, but local configuration/
administrative policy etc. directs HA to refer the MN to another HA,
the HA rejects the Request with error code REDIRECT-HA-REQ. The HA
fills in the address of the Redirected HA in the Redirected HA
Extension. The HA then sends Registration Reply reject to the FA,
which is formatted as follows:

```
+-------------------------------------------------------------+
| Src IP=| Dest IP =  | MN HoA  |    HA Address =   | CoA = |
|        | Src IP of  |         |        HA         |FA CoA |
|   HA   | the RRQ    |         |                   |       |
+-------------------------------------------------------------+
| Redirected HA Extension ...                                 |
+-------------------------------------------------------------+
```

4.   The FA relays the Registration Reply to the MN, as follows.

```
+-------------------------------------------------------------+
| Src IP=| Dest IP =  | MN HoA  |    HA Address =   | CoA = |
|   FA   |    MN      |         |        HA         |FA CoA/|
+-------------------------------------------------------------+
| Redirected HA Extension ...                                 |
+-------------------------------------------------------------+
```

5.   If the MN can authenticate the Reply, the MN extracts the HA
address from the Redirected HA Extension. The MN then sends a
Registration Request to the Redirected HA, unless it has already
received a redirection response from that HA while processing the
Registration Request. The MN may choose to add Requested HA
extension in this new Registration Request.

5. Mobility Agent Considerations

The following sections describe the behavior of each mobility agent
in detail.

5.1 Mobile Node Considerations

The mobile node MUST use the NAI extension for home address

assignment when using the messaging mechanism in this document.
Since MN uses the NAI extension, the Home Address field is set to
0.0.0.0.

While dynamic HA assignment is in progress and the MN has not
successfully anchored at a Home Agent, the MN MUST set the Home Agent
field in the Registration Request to an ALL-ZERO-ONE-ADDR, which is
either 255.255.255.255 or 0.0.0.0.

The Registration Request MUST be protected by a valid authenticator
as specified in Mobile IPv4 [1] or Mobile IPv4 Challenge/Response
Extensions [5]. Configuring security associations is deployment
specific and hence outside the scope of this specification. The
security associations between a MN and an individual HA may also be
dynamically derived during the dynamic HA assignment, based on a
shared secret between MN and AAA infrastructure [7].

The mobile node MUST maintain the remaining Mobile IP session with
the Assigned HA.

As mentioned in the Security Considerations (Section 9), there is a
possibility of more than one HA create a mobility binding entry for a
given MN, if a rogue node in the middle captures the Registration
Request and forwards it to other Home Agents. MN can mitigate such
condition by using a short lifetime (e.g. 5 seconds) in the
Registration Request with Home Agent field set to ALL-ZERO-ONE-ADDR.

The following sections describe MN behavior in FA CoA mode and co-
located CoA mode.

5.1.1 MN using FA CoA

When a mobile node initiates a Mobile IP session requesting dynamic
HA assignment, it MUST set the home agent address field in the
Registration Request to ALL-ZERO-ONE-ADDR. The destination IP
address of the Registration Request is the FA. The FA will determine
the Requested HA and forward the Registration Request to the
Requested HA. Registration Request processing takes place on the
Requested HA as per the specification in this draft.

The Registration Request MUST be appropriately authenticated for the
HA to validate the Request.

If a successful Registration Reply is received, the MN obtains the
Assigned HA from the HA field of Reply. The Assigned HA address will
be the same as the Requested HA Extension, if it was included in the
Registration Request by the MN.

If a Registration Reply is received with code REDIRECT-HA-REQ, the MN
MUST authenticate the Reply based on HA address in HA field of Reply
and attempt Registration with the HA address specified in the

Redirected HA Extension. The MN MUST put the Redirected HA address
as the Requested HA Extension of the new Registration Request.

In some cases, for the first Registration Request the MN may want to
hint to the network to be anchored at a specific HA. The MN SHOULD
put that address in the HA address of the Requested HA Extension.

5.1.2 MN using Co-located CoA

An MN in co-located CoA mode requesting dynamic HA assignment MUST
set the home agent address field in the Registration Request to ALL-
ZERO-ONE-ADDR. The destination IP address of the Registration
Request is the Requested HA. Some ideas on how to select a Requested
HA are briefly covered in section 6.

If a successful Reply is received, the MN obtains the Assigned HA
address from the successful Registration Reply. The Assigned HA will
be the same as Requested HA to which the Registration Request was
sent. The MN MUST cache the Assigned HA address for the length of
the Mobile IP session. The mobile node then MUST use this previously
cached Assigned HA address as the home agent address in subsequent
re-registration and de-registration request(s). This will make sure
that for the duration of the Mobile IP session, the mobile node will
always be anchored to the assigned home agent with which it was
initially registered.

If a Registration Reply is received with code REDIRECT-HA-REQ, the MN
MUST authenticate the Reply based on HA address in HA field of Reply
and attempt Registration with the HA address specified in the
Redirected HA Extension. The MN MUST put the Redirected HA in the
Requested HA Extension of the new Registration Request.

In some cases, for the first Registration Request MN may want to hint
to the network to be anchored at a specific HA and the MN SHOULD put
that address in the HA address of the Requested HA Extension.

While requesting dynamic HA assignment and registering directly with
an HA, the Requested HA Extension MUST be included and MUST contain
the address of the HA to which the Registration Request is sent.
When using co-located CoA but registering via a legacy FA, the HA
field in Reqistration Request may be set to Requested HA.

If the Registration Request contains the Requested HA Extension, the
HA address in that extension MUST match the destination IP of the
Request.

5.1.3 Refreshing Assigned HA Address on Mobile Node

When the Mobile IP session terminates, the mobile node MAY clear the
Assigned HA address cached as the home agent address. It MAY request

a new HA address for the new Mobile IP session by not including the
Requested HA Extension. The advantage of this approach is that the

   mobile node will be always anchored to an optimal home agent from
   where it initiated the Mobile IP session.

   Alternately, the MN may save the Assigned HA address and use it in
   the Requested HA Extension along with ALL-ZERO-ONE-ADDR HA address in
   Registration Request for a new Mobile IP session.

5.2 Foreign Agent Considerations

   When the mobile node is using a FA CoA it always registers via the
   FA. When the MN is using a co-located CoA it may register through a
   FA or it may register directly with an HA, unless the R bit is set in
   the FA's agent advertisement, in which case it always registers
   through the FA.

   When the FA receives a Registration Request with HA address field set
   to ALL-ZERO-ONE-ADDR that doesn't contain the Requested HA Extension,
   the FA obtains the Requested HA address to forward the Registration
   Request using means outside the scope of this specification. Some
   ideas on how to select a Requested HA are briefly covered in section
   6.

   If the FA cannot obtain the Requested HA to which to forward a
   Registration Request from MN, it MUST reject request with error code
   NONZERO-HA-REQD.

   If the MN has included the Requested HA Extension, the FA MUST
   forward Registration Request to the address in this extension. If
   the HA address in this extension is not a routable unicast address,
   the FA MUST reject request with error code NONZERO-HA-REQD.

   If the Registration Request contains the Requested HA Extension, the
   FA uses that address as the destination for the relayed Registration
   Request.

   Backward compatibility issues related to the mobility agents are
   addressed in section 10.

5.3 Home Agent Considerations

   A Home Agent can process an incoming Registration Request in one of
   the following two ways:

   1. The MN or FA sends the Registration Request to the Requested HA.
   The term Requested HA has meaning in the context of a Registration
   Request message. When the Requested HA successfully processes the
   Registration Request and creates a binding and sends a Reply with its
   address, it becomes the Assigned HA. The term Assigned HA is

meaningful in the context of a Registration Reply message.

2. A Home Agent receiving a Registration Request with HA field set
to ALL-ZERO-ONE-ADDR MAY reject the request even if successfully
authenticated and suggest an alternate HA address in Reply. In such
a case, the HA puts its own address in HA field of Reply and sets the
Reply code to REDIRECT-HA-REQ and adds the Redirected HA Extension.

If the Registration Request contains the Requested HA Extension, the
HA address in that extension must match the destination IP of the
Request. If it does not match, the Requested HA MUST reject the
Registration Request with error code 136.

5.3.1 Assigned Home Agent Considerations

The HA that processes the incoming Registration Request fully in
accordance with Mobile IPv4 [1] and this specification becomes the
Assigned HA. The Registration Request terminates at the Assigned HA.

The Assigned HA creates one mobility binding per MN and sends
Registration Reply to the MN by copying its address in the home agent
field and as the source IP address of the Reply.

The following table summarizes the behavior of the Assigned HA, based
on the value of the destination IP address and Home Agent field of
the Registration Request.

Dest IP Addr	HA field	Processing at Assigned HA
Unicast (Must be equal to the HA receiving the RRQ)	non-unicast	Mobile IPv4 [1]: There is no change in handling for this case from Mobile IPv4. It is mentioned here for reference only. HA denies the registration with error code 136 and sets HA field to its own IP address in the reply as per section 3.8.3.2 in [1].
	ALL-ZERO- ONE-ADDR	New Behavior: Accept the RRQ as per this specification. Authenticate the RRQ and create mobility binding if the HA is acting as Assigned HA. Set HA field to its own IP address in the Registration Reply. OR New Behavior: If authentication is

successful, reject RRQ with a new
error code REDIRECT-HA-REQ. HA

                              puts its address in HA address
                              field of Reject. HA suggests an
                              alternate HA to use in the new
                              Redirected HA Extension.

   Table 1: Registration Request handling at Assigned HA

   As per the messaging proposed here, the mobile node (or the foreign
   agent) sends the Registration Request to the Requested HA address,
   which is a unicast address. Therefore, this document does not
   specify any new behavior for the case where the HA receives a subnet
   directed broadcast Registration Request as specified in section
   3.8.2.1 of the Mobile IPv4 specification [1].   Although the Home
   Agent field in the Registration Request is not a unicast address, the
   destination IP address is a unicast address.   This avoids the
   problem associated with subnet-directed broadcast destination IP
   address that may result in multiple HAs responding.   Thus, there is
   no need to deny the registration as stated in Mobile IPv4 [1] section
   3.8.3.2.

   When the destination IP address is a unicast address and the Home
   Agent field is ALL-ZERO-ONE-ADDR, the HA accepts/denies registration
   and sets the HA field to its own IP address in the reply (i.e. the
   registration is not rejected with error code 136).

   The HA can reject the request with the error code REDIRECT-HA-REQ and
   suggest an alternate HA. This redirection can be used for load
   balancing, geographical proximity based on care-of-address or other
   reasons. The HA puts its own address in HA field of the Registration
   Reply message and puts the address of the redirected HA in the
   Redirected HA Extension. If the HA accepts the Request, it sets the
   HA field in the Registration Reply to its own address.

   The Requested HA always performs standard validity checks on the
   Registration Request. If there is any error, the Registration
   Request is rejected with error codes specified in Mobile IPv4 [1].

6. Requested Home Agent Selection

   When dynamic HA assignment is requested, the MN (or FA in the case of
   registration via FA) sends the Registration Request to the Requested
   HA.   This address MUST be a unicast IP address. If the MN has
   included a Requested HA Extension in Registration Request, the HA
   address in this extension is the Requested HA.

   Some example methods by which the MN or the FA may select the
   Requested HA are briefly described below:

DHCP:

MN performs DHCP to obtain an IP address on the visited network. The
Requested HA is learned from the DHCP Mobile IP Home Agent Option 68
[4]. MN sends Registration Request directly to this HA and receives
the Assigned HA to be used for the remainder of the Mobile IP
session.

AAA:

MN performs challenge/response [5] with the FA. The FA retrieves the
Requested HA from the AAA server and forwards the Registration
Request directly to this HA.   The Assigned HA sends a Registration
Reply to the FA, which relays it to the MN.   MN uses the Assigned HA
for the remainder of the Mobile IP session.

DNS:

In this case the hostname of the HA is configured on the MN or
obtained by some other means; e.g., using a service location
protocol. MN performs DNS lookup on the HA hostname. The DNS
infrastructure provides a resource record with information to
identify the optimal HA to the MN. The MN sends a Registration
Request directly to the HA and receives the Assigned HA to be used
for remainder of the Mobile IP session.

Static configuration:

The HA address is statically configured on the MN. The MN sends the
Registration Request to the configured address. The Requested HA may
then redirect the MN to a Redirected HA.

7. Error Values

Each entry in the following table contains the name and value for the
error code to be returned in a Registration Reply. It also includes
the section in which the error code is first mentioned in this
document.

Error Name	Value	Section	Description
NONZERO-HA-REQD	XX	5.2	Non-zero HA address required in Registration Request.
REDIRECT-HA-REQ	YY	5.3	Reregister with redirected HA.

8. IANA Considerations

The code value NONZERO-HA-REQD is a Mobile IP response code [1] taken from the range of values associated with rejection by the foreign agent (i.e. value in the range 64-127).

The code value REDIRECT-HA-REQ is a Mobile IP response code [1] taken from the range of values associated with rejection by the home agent (i.e. value in the range 128-192).

The Dynamic HA Extension is assigned from the range of values associated with skippable extensions at the home agent (i.e. value in the range 128-255).

IANA should record the values as defined in Section 7 and 3.4.

9. Security Considerations

This specification assumes that a security configuration has been preconfigured between the MN and the HA or is configured along with the initial Registration Request/Registration Reply as per [7].

There is a possibility of more than one HA create a mobility binding entry for a given MN, if a man in the middle captures the Registration Request with HA field set to ALL-ZERO-ONE-ADDR and forwards it to other HAs. This scenario assumes that the rogue node can find out the addresses of the HAs which are able to authenticate the Registration Request. It also assumes that the rogue node has the capability to store, duplicate, and send packets to the other HAs within the limited time of the replay window. Otherwise these HAs will reject the Registration Requests anyway. In addition, this type of attack is only possible when the Requested HA Extension is not included in the registration message. The Mobile Node can minimize the duration of this condition by using a short lifetime (e.g. 5 seconds) in the Registration Request.

This specification does not change the security model established in Mobile IPv4 [1]. Mobile Nodes are often connected to the network via wireless links, which may be more prone to passive eavesdropping or replay attacks. Such an attack might lead to bogus registrations or redirection of traffic or denial of service.

As per the messaging in this draft, the Assigned Home Agent will process the incoming Registration Request as per Mobile IPv4 [1]. Hence the Assigned Home Agent will have same security concerns as that of the Home Agent in Mobile IPv4 [1]. They are addressed in Section 5 "Security Considerations" of Mobile IPv4 [1].

The Registration Request and Registration Reply messages are protected by a valid authenticator as specified in Mobile IPv4 [1].

Configuring security associations is a deployment specific issue and
is covered by other Mobile IP specifications. There can be many ways

of configuring security associations, but this specification does not
require any specific way.

An example is where the security association between an MN and an
individual HA (Requested or Assigned) is dynamically derived during
the registration process based on a shared secret between MN and AAA
infrastructure, as defined in [7]. The Registration Request is
protected with MN-AAA authentication extension and Registration Reply
is protected with MN-HA Authentication Extension. Because the
security association is shared between MN and AAA, any dynamically
assigned HA in the local domain can proxy authenticate the MN using
AAA as per [7].

The Assigned Home Agent authenticates each Registration Request from
the mobile node as specified in Mobile IPv4 [1] and/or RFC-3012. The
MN also authenticates the Registration Reply from the Assigned HA,
thus the existing trust model in Mobile IPv4 [1] is maintained.

10. Backward Compatibility Considerations

In this section, we examine concerns that may arise when using this
specification in a mixed environment where some nodes implement the
specification and others do not.   In each of the examples below, we
consider the case where one node is a "Legacy" node which does not
implement the specification in the context of other nodes which do.

Legacy Home Agent:

Legacy home agents may reject the Registration Request with error
code 136 because the Home Agent field is not a unicast address.
However, some legacy HA implementations may coincidentally process
the Registration Request in accordance with this draft, when the HA
field in Registration Request is set to ALL-ZERO-ONE-ADDR.

Legacy Foreign Agent:

Legacy foreign agents may forward a Registration Request with home
agent field set to ALL-ZERO-ONE-ADDR by setting the destination IP
address to ALL-ZERO-ONE-ADDR.   This will result packet being dropped
or incidentally handled by a next hop HA, adjacent to the FA.   The MN
may not be aware of the dropped Registration Request and may probably
retry registration, thereby increasing the delay in registration.

To reduce the delay in registration, the MN should take following
steps:

1. The MN should send the Registration Request as specified in this
   specification. In other words, the MN should set the home agent

field in the Registration Request to ALL-ZERO-ONE-ADDR and also add
the Requested HA Extension.

  2. If the MN does not receive a Registration Reply within some time
     and/or after sending a few Registration Requests, it can assume
     that the Registration Request(s) has been dropped, either by a
     legacy FA or an incorrect HA. In addition, if the registration is
     denied with error code 70 (poorly formed Request), the MN can
     assume that the legacy FA cannot process this message. In either
     case, the MN should fall back to a recovery mechanism. The MN
     should quickly send a new Registration Request as mentioned in
     section 4.1 step 2. This step will ensure that a legacy FA will
     forward the Registration Request to the Home Agent thereby making
     dynamic HA assignment possible.

   Legacy Mobile Node:

    A MN that sends a registration request to an FA which can do dynamic
    HA assignment, but does not set the HA field to ALL-ZERO-ONE-ADDR
    will continue to be registered with its statically configured HA,
    exactly according to RFC 3344.

11. Change Log from previous versions

   Note: This section should be removed before publication.

   Changes from revision 6 to 7:

     1. Updated section 4.2 bullet 5.

   Changes from revision 5 to 6:

     2. Updated section 4.2.1 bullet 5.
     3. Fixed nits found by idnit tool.
     4. Added text in section 5.1 outlining how to avoid the
        possibility of multiple bindings on HAs by requiring short
        lifetime for first registration request.
     5. Added text in section 9 outlining possibility of multiple
        bindings on HAs.
     6. Added text in section 12 Acknowledgements.

   Changes from revision 4 to 5:

     1. Legacy FA Considerations text was updated based on the WG
        discussions which addressed IESG review feedback.

   Changes from revision 3 to 4:

     1. Text added to clarify the cases when MN is configured with HA
        address and not configured with HA address and requests

dynamic HA assignment.

2. Clarification on legacy FA section as suggested by Thomas
   Narten.
3. More editorial changes suggested by the chairs.

Changes from revision 2 to 3:

1. More editorial changes suggested by the chairs.

Changes from revision 1 to 2:

1. Editorial changes suggested by the WG, the chair's reviews and
   idnits.

Changes from revision 0 to 1:

1. Added subtype field in Redirected HA Address Extension.
2. Aligned the HA address at 4-byte world boundary.
3. The case of handling unicast HA field is removed in section
   5.3.1.

12. Acknowledgements

The authors would like to thank Pete McCann for thorough review,
suggestions on security considerations and definition of ALL-ZERO-
ONE-ADDR. Thanks to Kuntal Chowdhury for extensive review and
comments on this draft. Also thanks to Henrik Levkowetz for detailed
reviews and suggestions. Thomas Narten highlighted issues for legacy
FA considerations. Thanks to Ahmad Muhanna for pointing out scenario
of multiple bindings on HAs, documented in the Security
Considerations section.

The authors would like to thank Mike Andrews, Madhavi Chandra and
Yoshi Tsuda for their review and suggestions.

13. Normative References

[1] C. Perkins, "IP Mobility Support for IPv4", RFC 3344, August
     2002.
[2] P. Calhoun and C. Perkins, "Mobile IP Network Access Identifier
     Extension for IPv4", RFC 2794, March 2000.
[3] D. Senie, "Changing the Default for Directed Broadcasts in
     Routers", RFC 2644, August 1999.
[4] S. Alexander and R. Droms, "DHCP Options and BOOTP Vendor
     Extensions", RFC 2132, March 1997.
[5] C. Perkins and P. Calhoun, "Mobile IPv4 Challenge/Response
     Extensions", RFC 3012, November 2000.
[6] Bradner, S., "Key words for use in RFCs to Indicate Requirement

Levels", BCP 14, RFC 2119, March 1997.

  [7] C. Perkins and P. Calhoun, "AAA Registration Keys for Mobile
       IP", draft-ietf-mip4-aaa-key-06.txt, June 2004.

Authors' Addresses

    Milind Kulkarni
    Cisco Systems Inc.
    170 W. Tasman Drive,
    San Jose, CA 95134
    USA

    Email: mkulkarn@cisco.com
    Phone:+1 408-527-8382

    Alpesh Patel
    Cisco Systems Inc.
    170 W. Tasman Drive,
    San Jose, CA 95134
    USA

    Email: alpesh@cisco.com
    Phone:+1 408-853-9580

    Kent Leung
    Cisco Systems Inc.
    170 W. Tasman Drive,
    San Jose, CA 95134
    USA

    Email: kleung@cisco.com
    Phone: +1 408-526-5030

Intellectual Property Statement

    The IETF takes no position regarding the validity or scope of any
    Intellectual Property Rights or other rights that might be claimed to
    pertain to the implementation or use of the technology described in
    this document or the extent to which any license under such rights
    might or might not be available; nor does it represent that it has
    made any independent effort to identify any such rights.
    Information on the procedures with respect to rights in RFC documents
    can be found in BCP 78 and BCP 79.

    Copies of IPR disclosures made to the IETF Secretariat and any
    assurances of licenses to be made available, or the result of an
    attempt made to obtain a general license or permission for the use

of such proprietary rights by implementers or users of this

specification can be obtained from the IETF on-line IPR repository
at http://www.ietf.org/ipr.

The IETF invites any interested party to bring to its attention
any copyrights, patents or patent applications, or other
proprietary rights that may cover technology that may be required to
implement this standard. Please address the information to the IETF
at ietf-ipr@ietf.org.

Disclaimer of Validity

This document and the information contained herein are provided on an
"AS IS" basis and THE CONTRIBUTOR, THE ORGANIZATION HE/SHE REPRESENTS
OR IS SPONSORED BY (IF ANY), THE INTERNET SOCIETY AND THE INTERNET
ENGINEERING TASK FORCE DISCLAIM ALL WARRANTIES, EXPRESS OR IMPLIED,
INCLUDING BUT NOT LIMITED TO ANY WARRANTY THAT THE USE OF THE
INFORMATION HEREIN WILL NOT INFRINGE ANY RIGHTS OR ANY IMPLIED
WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

Copyright Statement

Acknowledgement