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        A solution for vertical handover of multimedia sessions using SIP
             draft-salsano-sipping-siphandover-solution-02

Status of this Memo

Abstract

   This document proposes a solution for handling vertical handovers
   among different network technologies using SIP, fulfilling a set of
   requirements discussed in the document "Requirements for vertical
   handover of multimedia sessions using SIP"
   (draft-niccolini-sipping-siphandover-03). The solution requires a
   new header field (named "Handover") and a new parameter in the Via
   header field (named "MMID").

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1. Introduction

   A set of requirements for vertical handover using SIP has been
   discussed in [niccolini-sip-HO]. Figure 1 reports the scenario under
   consideration. In short, the requirement is to allow a Mobile Host
   to roam over different access networks using both public and private
   IP addresses, minimizing service disruption due to mobility, without
   relying on Correspondent Host functionality and even hiding to the
   Correspondent Host the movements of the Mobile Host. In this
   document we describe a possible solution to these requirements (and
   all the other ones listed in [niccolini-sip-HO]). The solution
   requires a new header field (named "Handover") and a new parameter in
   the Via header field (named "MMID"). The new header and new
   parameter will only be added and processed by the entities directly
   involved in the management of the mobility, with no impact on other
   SIP entities.

```
                       +--------+
                       |  AN1   |-----+
                  ----|        | NAT |                +--------+
                 /     +-------+-----+                |Corresp.|
    +-------+                        _____       | Host 1 |
    | Mobile|       +-------+       /          \      +--------+
    | Host  |       |  AN2  |      /            \
    +-------+   ----|       |     |   INTERNET   |
                    + - - - +      \            /
                                    _____/
            \      +-------+                        +--------+
             ----|  AN3   |-----+            +-----|Corresp.|
                 |        | NAT |            | NAT | Host 2 |
                 +-------+-----+             +-----+--------+
```
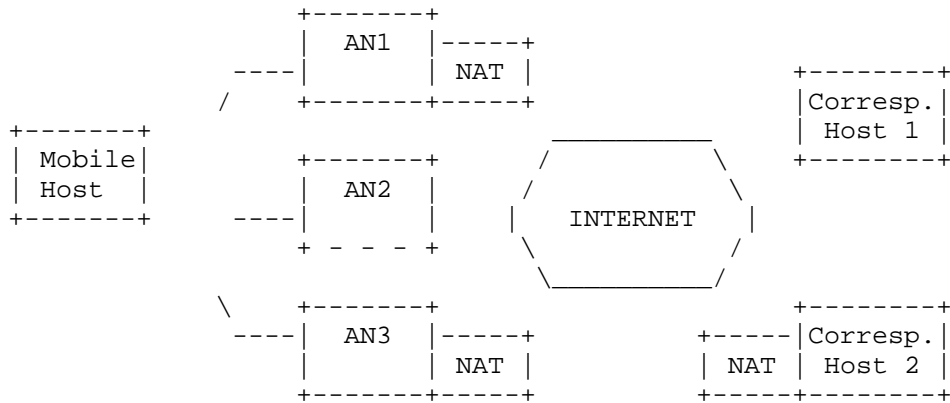
                 Figure 1: Scenario for Vertical Handover

   In Section 2 the architectural elements of the solution are
   presented. Section 3 describe the signalling procedures to realize
   the mobility management (both off-call and on-call) and the
   establishment of sessions. Section 4 and Section 5 specify the new
   parameters in the Via header field (named "MMID") and the new header
   field (named "Handover") that are required by the proposed solution.

2. Architecture of the proposed solution

   The elements of the proposed solution are shown in Figure 2. We
   assume that a Mobile Host (MH) is communicating with a Correspondent
   Host (CH). The MMS is the Mobility Management Server which is able
   to handle user mobility across different access networks and to
   perform the handover. The MMS cooperates with the MMC (Mobility
   Management Client) which resides on the Mobile Host. Figure 2 shows
   that NAT boxes can be inserted between the MH and the MMS. Figure 2
   shows a standard SIP trapezoid with the additional elements of this
   solution (MMS and MMC). Such figure is just for explanation
   purposes, the solution proposed here is not depending on the
   communication following the standard SIP trapezoid to work.

   The MMS is an "anchor point" for the media flows which are
   transmitted over the wireless access networks directed to (and coming
   from) the MH. When the MMC in the MH detects that a handover is
   needed, it will request the handover to the MMS (via a SIP message)
   over the "target" network. Then the MMS will update its media proxy
   and will start transmitting and receiving the media over the target
   network (details are provided in the next section). Note that the
   entire handover procedure is handled by the MH and the MMS, letting
   the CT (and other SIP intermediate nodes) completely unaware of what
   is occurring. For the sake of simplicity, we only describe here the
   solution considering a single centralized MMS. In real life, the MMS
   functionality may need to be distributed for scalability and
   reliability reasons.

   The Mobility Management Client can be implemented (as shown in
   Figure 2) as a separate entity running on the MH that masquerades all
   mobility and NAT traversal functionality by relaying both signaling
   and media flows. In this case the SIP User Agent sees the MMC as
   default "outbound proxy" (which means that the UA will send all SIP
   message to the MMC) and it has no knowledge of the handovers.
   Existing SIP UAs can be easily supported/reused without any changes.
   A different solution would be to integrate the MMC functionality
   within the UA, saving resources of the MH. These two solutions only
   differ in the internal implementation, while there is no difference
   in the external behavior of the procedures.

```
          Classical SIP UA          +-------+   +-------+
           Registration             | MH's  |---| CH's  |
          .................>         | Proxy |   | Proxy |
                  .                 /+-------+   +-------+\
                .                  /                       \
              .                   /                         \
            .                    /                           \
  Mobile Host    .              +-----+                       +----+
   +-------+    .               | MMS |-----------------------| CH |
   |+-----+|<...                +-----+                       +----+
   || UA  ||                   /  A
   |+-----+|                  /   .
   |+-----+|        +-----+  /    .
   || MMC ||--------| NAT |/      .   Mobile Host Mobility
   |+-----+|        `+-----+      .
   +---A---+                      .
       .                         .
         .                      .
           ....................
```
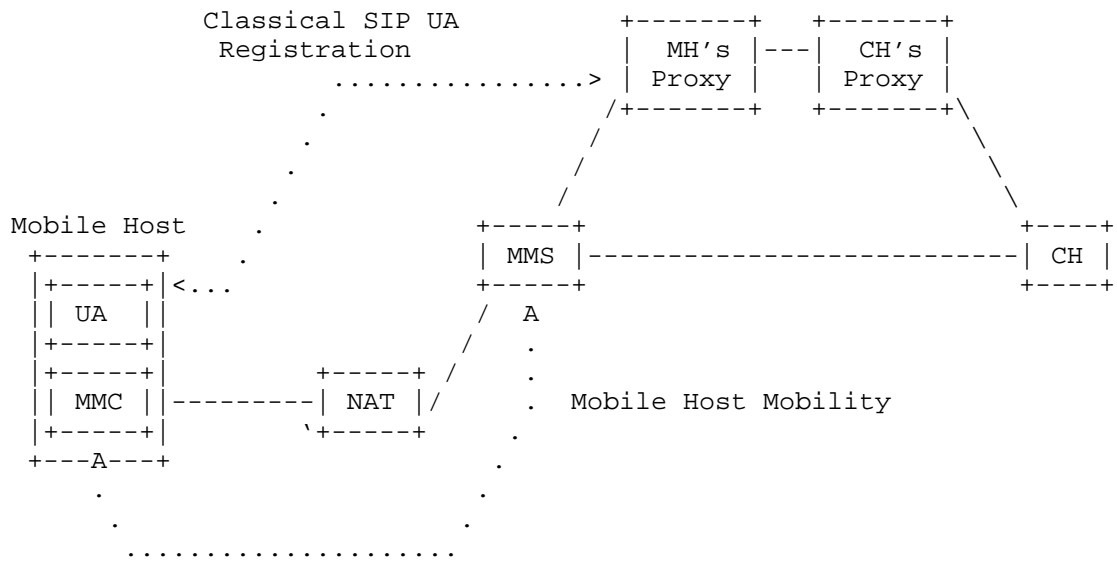
Figure 2: Architecture of the proposed solution

3. Signalling procedures

   This section describes the specific procedures for mobility
   management (off-call and on-call) and shows how the canonical SIP
   procedures (user registration and session establishment) are realized
   under the proposed solution. The procedure for mobility management
   related to the off-call part is meant to be used by the MH (UA+MMC)
   to tell the MMS about its current selected/active interface (or to
   communicate changes to such selection) when not in a call, for this
   we use regular REGISTER sent from the MMC to the MMS. The on-call
   mobility management related to the on-call part is meant to be used
   by the MH (UA+MMC) to tell the MMS about a change in its current
   selected/active interface when in a call, for this we use regular
   REGISTER sent from the MMC to the MMS with an additional "Handover"
   header which contains the reference to the active session(s) to which
   the handover is referred. In both cases an additional parameter to
   be added to the "Via" header for correct routing of responses to the
   MMC is needed and used.

3.1. Off-call mobility: Location Update (LU) Registration procedure

   The "Location Update" (LU) Registration is the basic mobility
   procedure that allows a MH to notify the MMS about its "position" (or
   better about its IP address) and select the currently preferred
   interface for sending/receiving SIP signaling and media flows. The
   sequence diagram of this procedure is shown in Figure 3. The MMC in
   the MH sends a standard REGISTER to the MMS over the selected/active
   interface. This procedure is activated at the start up of the MH (or
   when the MH first enters in a coverage area), or whenever the MH
   wants to change the selected/active interface if it is under coverage
   of more than one network. We can refer to this procedure as "off-
   call" mobility management because we assume that the MH is not
   engaged in a call. If the MH is engaged in a call, the handover
   procedure will be executed (see Section 3.4). When the 200 OK is
   received, a "keep-in-touch" mechanism is activated on that interface
   (and deactivated on the previous interface if needed) in order to
   keep the pinhole in the NAT open. Various techniques could be used
   for this purpose; we use periodic SIP REGISTER messages from MMC to
   MMS.

```
    +-------+       +-------+       +-------+       +-------+
    |  U A  |       |  MMC  |       |  MMS  |       | Proxy |
    +-------+       +-------+       +-------+       +-------+
        |               |               |               |
        |               |  LU REGISTER  |               |
        |               |=============>|               |
        |               |               |               |
        |               |    200  OK    |               |
        |               |<=============|               |
        |               |               |               |
        |               |               |               |
```
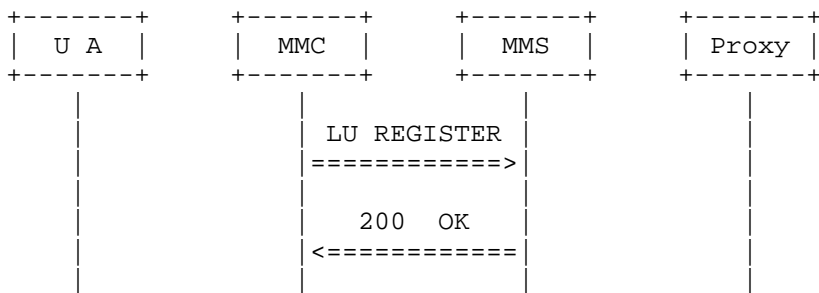
Figure 3: Location Update Procedure

As result of the Location Update Registration procedure, the MMS
becomes aware of the current position (i.e. IP address and port) of
the MH, and can correctly route any new request or response messages
addressed to the mobile UA (even across a NAT box). For each
registered user the MMS stores the IP address and port from which it
received the "Location Update" (LU) REGISTER. This information can
be stored by the MMS in a table that we call "MMS mobility database"
containing the MMS state. Such table is depicted in Figure 4.

```
-------------------------------------------------
|   User(terminal)     |    IP/port             |
-------------------------------------------------
|  user@domain.com     |  160.80.81.23:45678    |
|  user2@domain.com    |  87.3.235.212:23458    |
|  ...                 |  ...                   |
-------------------------------------------------
```

Figure 4: MMS mobility database

3.1.1. Extensions to SIP specifications

The Location Update Registration procedure does not require specific
extensions to the current SIP specification. A LU REGISTER will have
the MMS as target SIP URI in the request line. If the MMS only
handles LU REGISTERs there is no problem. If the MMS also handles
normal user registration REGISTER (i.e. it acts also as a SIP
registrar) the MMS needs to identify LU REGISTERs from normal user
REGISTER. In this case a specific SIP URI can be associated to the
LU REGISTER messages.

Anyway as will be discussed in Section 4, the MMC will add the new
parameter "MMID" in the Via header of the REGISTER, in order to have
the responses routed to current location (IP addresses) of the MH.

3.2. User Registration procedure

   This procedure consists in the UA registration with its own SIP
   Registrar server. The sequence diagram of this procedure is
   described in Figure 5. As any other SIP message, when the UA sends
   its own registration request to the SIP Registrar, the message is
   sent by the UA to the MMC which is seen as outbound proxy. The MMC
   forwards it to the MMS. Acting on behalf of the MH, the MMS will
   forward the registration to the SIP Registrar, which will update the
   contact address associated with the user's AoR (that is the public
   user identifier). When forwarding the REGISTER message, the MMS
   modifies the Contact header in such a way it becomes the new
   "contact" for the user. This is required in order to force the
   routing through the MMS of all further requests addressed to the
   user. Such mangling of the contact URL should be unique and
   reversible. Details on how to encode the user AoR in the new contact
   are provided below in Section 4.1. From now on, only the MMS will
   keep track of the MH movements, while the SIP Registrar will just
   believe that the MH location is the IP address of the MMS.

```
         +-------+       +-------+       +-------+     +---------+
         | U A   |       | MMC   |       | MMS   |     |MH'sProxy|
         +-------+       +-------+       +-------+     +---------+
             |   REGISTER    |               |             |
             |============>  |               |             |
             |               |   REGISTER    |             |
             |               |============>  |             |
             |               |               |   REGISTER  |
             |               |               |============>|
             |               |               |   200  OK   |
             |               |               |<============|
             |               |   200  OK     |             |
             |               |<============  |             |
             |   200  OK     |               |             |
             |<============  |               |             |
             |               |               |             |
```
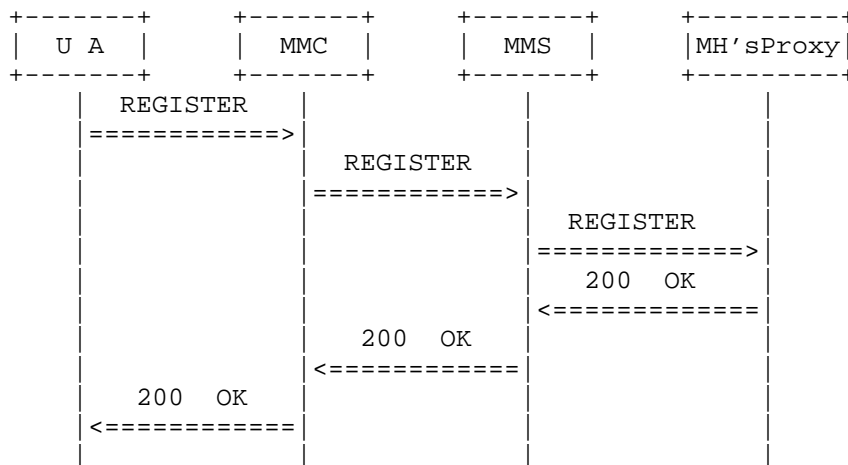
                    Figure 5: User Registration

3.2.1. Extensions to SIP specifications

   The User Registration procedure requires that the MMS rewrites the
   contact address as will be described Section 4.1. Anyway, this does
   not need to be subject of specification as it only concerns the MMS.
   All other entities will simply handle the rewritten contact according
   to current SIP specification. As will be discussed in Section 4, the
   MMC will add the new parameter "MMID" in the Via header of the
   REGISTER messages, in order to have the responses routed to current

location (IP addresses) of the MH.

3.3. Session Establishment procedure

The session establishment procedure consists in a standard SIP
session setup procedure. All session establishment messages for MH
are handled by the MMS. Before relaying an INVITE request sent by
the caller and the corresponding 200 OK response sent by the callee
the MMS modifies the corresponding SDP bodies in order to act as RTP
proxy for media flows in both directions. This is needed to
correctly handle NAT traversal in the path towards the MH, and it is
done by using the symmetric RTP approach. Once the session is
established, the media packets start to flow over the selected
wireless interface. Figure 6 shows a session establishment from CH
to MH.

```
UserAgent       MMC           MMS          MH's Proxy   CH's Proxy        CH
 |               |             |             |            |             |
 |               |             |             |            |   INVITE    |
 |               |             |             |   INVITE   |<===========|
 |               |             |   INVITE    |<===========|            |
 |               |   INVITE    |<===========|            |             |
 |    INVITE     |<===========|             |            |             |
 |<===========|             |             |            |             |
 |    200  OK    |             |             |            |             |
 |===========>|   200  OK    |             |            |             |
 |               |===========>|   200  OK    |            |             |
 |               |             |===========|   200  OK    |            |
 |               |             |             |===========>|   200  OK   |
 |               |             |             |            |===========>|
 |               |             |             |            |   ACK       |
 |               |             |             |    ACK     |<===========|
 |               |             |    ACK      |<===========|            |
 |               |    ACK      |<===========|            |             |
 |    ACK        |<===========|             |            |             |
 |<===========|             |             |            |             |
 |               |             |             |            |             |
```
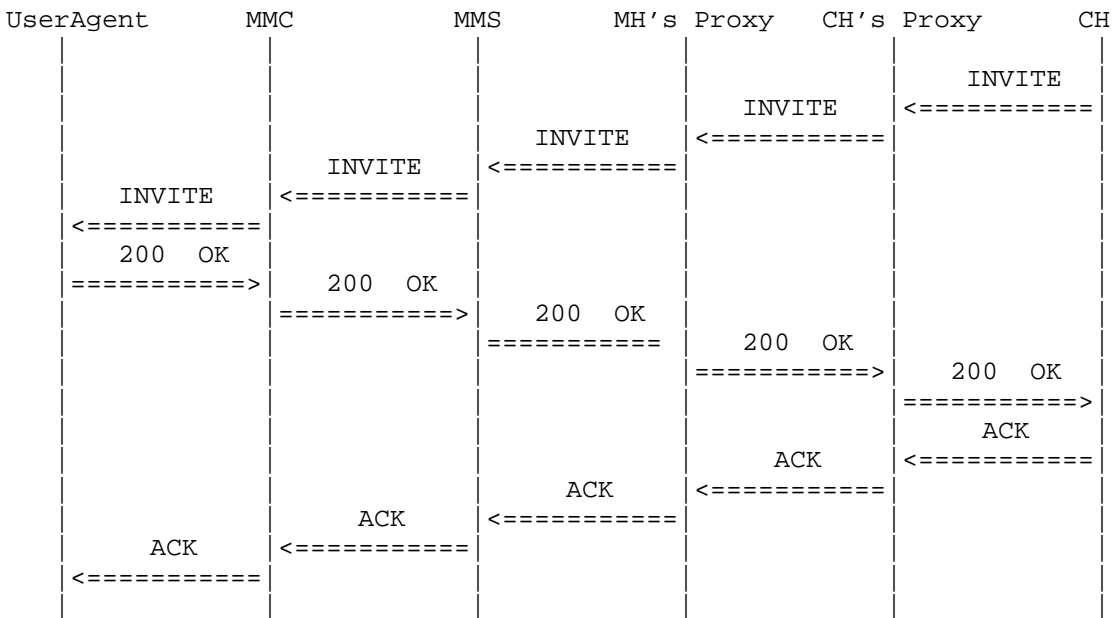
Figure 6: Session Establishment

The MMS needs to keep a state information related to the active flows
as it is performing a media relay functionality. In order to
correclty perform the handover procedure, we require that this state
information is accessible using the current call as key. SIP
identifies a call by means of the Call-ID, the From and To header
fields. Therefore the MMS maintains an "MMS call database", see
Figure 7. For each call and for each media flow the information of

two "legs" (MH-MMS and CH-MMS) need to be stored . For each leg the local and remote IP addresses and port of the media flows are stored. As shown in Figure 7 the legs are stored as "originating" leg (i.e. the leg connecting the MMS with the user in the "From" header) and terminating leg (i.e. the leg connecting the MMS with the user in the "To" header). In Figure 7 only one media media flow per call, while in general more than one media flow can be associated to a call.

```
---------------------------------------------------------------------
| Call                      | Originating leg  | Terminating leg  |
---------------------------------------------------------------------
|Call-ID:F16@192            |Local:            |Local:            |
|From:<sip:user1@domain.com>|160.80.81.23:4345 |160.80.81.23:4569 |
|;tag=871                   |Remote:           |Remote:           |
|To:<sip:user2@domain.com>  |151.2.82.21:3824  |87.3.235.212:3458 |
|;tag=345                   |                  |                  |
---------------------------------------------------------------------
|Call-ID:xcv@1sfdsf.sdf     |Local:            |Local:            |
|From:<sip:user3@domain.com>|160.80.81.23:8732 |160.80.81.23:7745 |
|;tag=sgf                   |Remote:           |Remote:           |
|To:<sip:user5@domain.com>  |87.3.233.12:23458 |151.8.48.2:3456   |
|;tag=dsw                   |                  |                  |
---------------------------------------------------------------------
```

Figure 7: MMS call database

3.3.1. Extensions to SIP specifications

The User Registration procedure requires that the MMS rewrites the contact address as will be described Section 4.1. Actually, this is not a matter of specification as it only concerns the MMS. All other entities will simply handle the rewritten contact according to current SIP specification. As will be discussed in Section 4, the MMC will add the new parameter "MMID" in the Via header of the REGISTER messages, in order to have the responses routed to current location (IP addresses) of the MH.

3.4. On-Call Mobility: Handover procedure

The on-call mobility management procedure takes place when the UA identifies the need for handoff during an ongoing session. In our proposal, all the handover signaling messages can be exchanged on the target network (this approach is commonly referred to as "forward" handover). Therefore the handover can be performed even if the communication on the old network is interrupted abruptly. The handover procedure (see Figure 8) is initiated by the MH. The MMC in the MH sends an "HandOver" (HO) REGISTER over the target network interface addressed to the MMS. Differently from a "Location Update"

(LU) REGISTER, the "HandOver" (HO) REGISTER request contains in the message body the reference to the active session(s) to which the handover is referred. At the same time, the MH starts duplicating the outgoing media packets on both interfaces (unless the old interface has gone down). As soon as the MMS receives the "HandOver" (HO) REGISTER, it starts accepting packets coming from the new interface and discarding the ones coming from the old interface for the active session(s) to be handed over. Then it sends back the 200 OK to the MMC and it starts sending the media packets directed to the MH using the new interface. Thanks to the fact that the terminal has already started sending the packets on the new interface, the duration of the handover is minimized. The most critical issue is that the "HandOver" (HO) REGISTER could be lost for any reason, delaying the handoff procedure. The standard SIP procedure foresees that the client performs a set of retransmission of the "HandOver" (HO) REGISTER if the 200 OK is not received back. The SIP specification suggests a default value of the T1 retransmission timeout equal to 500 ms, that is doubled on each retransmission (up to the value of T2 which by default is 4 s). The duration of the ritrasmission is 64*T1. However this is not compatible with a reasonable performance of the handover in case of the loss of the "HandOver" (HO) REGISTER. We propose the the timers for the "HandOver" (HO) REGISTER procedure should be set to lower values, like for example: T1 = 50 ms, T2 = 250 ms. On the MH side, the MMC will stop duplicating the packets on both interfaces as soon as the 200 OK is received or the first media packet is received on the new interface. Note that if the media packet is received, but no 200 OK message, the MMC will still continue sending the "HandOver" (HO) REGISTER until the REGISTER transaction expires.

```
+-------+     +-------+     +-------+     +-------+
|  U A  |     |  MMC  |     |  MMS  |     | Proxy |
+-------+     +-------+     +-------+     +-------+
    |             |             |             |
    |             | HO REGISTER |             |
    |             |============>|             |
    |             |             |             |
    |             |   200  OK   |             |
    |             |<============|             |
    |             |             |             |
```
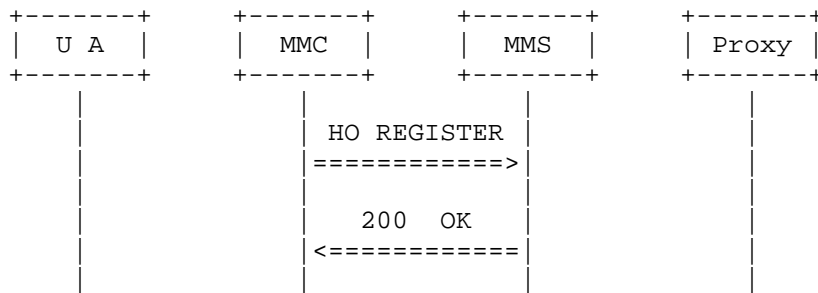
Figure 8: Handover REGISTER

3.4.1. Extensions to SIP specifications

   The on-call mobility management needs the definition of a new header
   field (see Section 5) to carry the identification of the call(s) to
   be handed over. This header field will be added by the MMC and
   handled by the MMS. Moreover, as will be discussed in Section 4, the
   MMC will add the new parameter "MMID" in the Via header of the
   REGISTER messages, in order to have the responses routed to current
   location (IP addresses) of the MH.

4. Routing of requests and responses

   In this section we detail how SIP messages are routed among the
   different entities. The challenge is to deliver incoming SIP
   requests and SIP responses to the MH, nonwithstanding its mobility.

   As for incoming SIP requests, when the UA in the MH performs the User
   Registration procedure (Section 3.2) the MMS rewrites the Contact
   header filed so that it points to the MMS itself. Therefore incoming
   requests for the MH will be forwarded by the SIP incoming proxy to
   the MMS. Similarly when outgoing requests are sent from the MH to a
   Correspondent Host the MMS will rewrite the Contact header so that
   the CH will consider the MMS as the destination of future requests to
   the MH. When incoming requests arrive to the MMS, the MMS will
   forward them to the current IP address of the MH, as updated by the
   MH using the Location Update procedure (Section 3.1).

   As for responses to outgoing SIP requests sent by the MH, the MMS
   adds a new parameter in the Via header field (see Section 4.2). This
   parameter is used by the MMS itself to route the response.

4.1. Use of Contact header field

   The solution foresees that the MMS rewrites the Contact header when
   forwarding outgoing SIP requests coming from the MH. The rewritten
   contact address will have as host part the IP address (or domain
   name) of the MMS, and as username part an hint to the original
   contact address. The procedure that binds the new username to the
   original contact address is just a matter of the MMS and is
   completely left to MMS implementation. There is no need to
   standardize the procedure for rewriting the Contact header. The only
   requirement is that such procedure MUST be reversible since the MMS
   needs to be able to rebuild the original Contact header field when
   receiving SIP requests addressed to the rewritten contact address.
   Obviously, the rewritten Contact header will be compatible with SIP
   specifications, so that all other involved entities will simply need
   to behave according to the standard.

   For example, a possible solution is that the MMS generates a pseudo-
   random string that is stored in a local database and used as key to
   retrieve the original Contact header field. Another possible
   solution is to embed the original contact in the rewritten contact so
   that no state information needs to be stored in the MMS. For
   example, assume that user's AoR is user@domain.com and the original
   Contact header inserted by the UA is:

   Contact: <sip:user@x.y.w.z:5080>

where x.y.w.z is the current IP address of the MH. The MMS can
rewrite the contact as follows:

Contact: <sip:/TOKEN-user/AT-x.y.w.z/PORT-5080@MMS_x.y.w.z>

Where MMS_x.y.w.z is the IP address of the MMS, "TOKEN-" is a string
that can be set by the MMS and "/" is used as escape character. When
receiving an incoming request with the request URI corresponding to
the above contact, the MMS will extract the original contact address
user@x.y.w.z:5080 and will forward the message according to the
information contained in its MMS mobility database.

4.2. MMID parameter in Via header field

According to SIP specification, each node in the request delivery
chain adds a Via header field with its own IP address when forwarding
the request, in order to be included in the response delivery chain.
We propose that the MMC adds an additional parameter to the Via
header. This parameter is called MMID (Mobility Management
IDentifier) and it carries the identifier of the MH. The MMID
parameter is used as an indication that the originator of the request
is a mobile host and it could change its IP address even during the
transaction. Therefore the value of the MMID will be used as a key
into the MMS mobility database, in order to find the current IP
address to send the response. With this mechanism, the solution is
able to deal in a seamless way with an handover performed during a
session establishment.

As an example, a Via header sent by the MMC to the MMS may look like
the following:

Via: SIP/2.0/UDP x.y.w.z;branch=z9h;MMID=user@domain.com

5. Handover: header

   When the MH needs to perform the handover during an active call, the
   MMC will send an "HandOver" (HO) REGISTER to the MMS. These message
   will perform the update of the MMS mobility database likewise the
   "Location Update" (LU) REGISTER, but in addition it will start the
   handover of the media flows belonging to the call. We insert a new
   header in the "HandOver" (HO) REGISTER, which includes the reference
   to the call to be handed over. The new header name will be
   "Handover:" and it will carry the Call-ID and the two tags, in a
   similar way to the Join header [refs.rfc3911] or to the Replaces
   header [refs.rfc3891]. In particular the parameters that carry the
   tags are called "req-tag" and "other-tag".

   Handover: sxdfv20000513@host.domain.com; req-tag=erfg; other-tag=wdfe

   The MMC requesting the handover will insert in the "req-tag" the tag
   corresponding to the MH in the INVITE transaction that originated the
   call (i.e. the From: tag if the call was originated by the MH or the
   To: tag if the call was originated by the CH). By comparing this
   information with the MMS call database (Figure 7), the MMS will be
   able to understand on which of the two legs of the call the handover
   has been requested.

6. Decoupling user level registration and terminal level registration

   One optional requirement discussed in [niccolini-sip-HO] was to allow
   the decoupling of "user level" registration and "terminal level"
   mobility. As an example a user with AOR "sip:user@domain.com" should
   be allowed to use different terminals (i.e. Mobile Hosts supporting
   the handover solutions as well as normal SIP terminals). In this
   document we did not explicilty consider this requirement, we assumed
   that the Mobile Host is identified by an AOR "sip:user@domain.com"
   and therefore this AOR can be used for only one Mobile Host.

   We only mention here that this requirement can be addressed in
   straighforward way by introducing the concept of a Terminal
   identifier, distinct by the user AoR. The MMC can use this Terminal
   identifier inserting it in the MMID parameters in Via header. The
   terminal identifier will become the key to retrieve information
   related to the MH in the MMS, rather then using the user's AoR.

7. Related work

   The general problem of continuity of multimedia sessions is currently
   heavily discussed in 3GPP and it was agreed to be studied in
   timeframe of Release 8. The handover that this document refers to is
   referred to as PS-PS session continuity in 3GPP terminology. 3GPP is
   considering the usage of an intermediate element in order to handle
   PS-PS multimedia session continuity as written in 3GPP Technical
   Report 23.893. The usage of such intermediate element is also the
   core point of the solution presented in [Salsano08], [Salsano07].
   Also the scenarios currently under discussion are inline with the
   scenario depicted in Section 2 (please note that the scenarios
   discussed in 3GPP are currently a superset of the one depicted in
   this document).

8. Conclusions

   This document presented a possible solution to the set of
   requirements discussed in [niccolini-sip-HO]. The solution requires
   a new header field (named "Handover") in order to support the
   handover of media flows during an active call and a new parameters to
   the Via header field in order to allow the correct routing of SIP
   responses to the MH even during an handover. The standardization of
   these two elements would allow the open interoperability of MHs and
   MMS. We note that variants of the described solution have been
   successfully implemented in some testbeds by the authors (see for
   example [Salsano08]). The motivation of this work assumes even more
   relevance if 3GPP interest in this kind of solutions is taken into
   account.

9. Security considerations

    A detailed analysis of the security aspects related to the proposed
    solution needs to be performed in order to check that no new
    additional security issues will be introduced with respect to a SIP
    solution that handles mobility using the traditional end-to-end based
    approach.

10. Informative References

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