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M. Liebsch
NEC

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Distributed Mobility Management - Framework & Analysis
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Abstract

Mobile operators consider the distribution of mobility anchors to enable offloading some traffic from their core network. The Distributed Mobility Management (DMM) Working Group is investigating the impact of decentralized mobility management to existing protocol solutions, while taking into account well defined requirements, which are to be met by a future solution. This document discusses DMM using a functional framework. Functional Entities to support DMM as well as reference points between these Functional Entities are introduced and described. The described functional framework allows distribution and co-location of Functional Entities and build a DMM architecture that matches the architecture of available protocols. Such methodology eases the analysis of best current practices with regard to functional and protocol gaps.

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1. Introduction

The concept of Distributed Mobility Management (DMM) in based on the distribution of mobility anchors towards the access networks to provide mobile nodes with local anchors and enable optimal routing of traffic above anchor level to any kind of serving point, e.g. distributed content caches. The closer mobility anchors are located to mobile nodes, the more a mobile node's handover may necessitate the assignment of a new mobility anchor. Continuity of a mobile node's IP address or IP address prefix enables IP session continuity, but creates the problem of routing downlink packets to the mobile node's current mobility anchor. Different solutions and associated extensions to IP mobility management protocols are being discussed to maintain a mobile node's IP session after mobility anchor relocation, including solutions that are based on existing protocols.

This document defines a framework for DMM and describes an initial set of well defined functional entities (FE), which are required to support IP address continuity in a network with distributed mobility anchors. Having identified the function of each FE as well as required interfaces between FEs allows different constellations of FEs, either by co-locating or distributing them. We consider such framework of particular importance for the discussion of Best Current Practices (BCP) to enable DMM, and for performing a Gap Analysis while assigning the defined FEs to architecture components of existing protocols.

The initial version of this draft introduces a basic set of FEs and interfaces between these FEs to support IP address continuity in DMM, without being specific to the used mobility management protocol, which operates below the mobility anchor.

2. Conventions and Terminology

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

3. Functional Architecture for DMM Support

The framework introduces five functional entities (FE) which are relevant to DMM to meet essential DMM requirements as per [I-D.ietf-dmm-requirements], such as enabling temporary IP address continuity after a mobile node got assigned a new mobility anchor. Further FEs may be needed to enable advanced features, such as simultaneous use of an imported mobile node HoA or HNP to maintain ongoing data sessions and a new HoA or HNP, which is allocated by the mobile node's new mobility anchor after handover. Additional FEs are not considered in this first version of the draft, but can be introduced easily in future versions of the draft and considered for the BCP discussion and gap analysis.

The following FEs are considered so far to suit basic DMM requirements:

- FE_R: Functional Entity of a standard IP Router / Switch

- FE_MA: Functional Entity Mobility Anchor

- FE_MCTX: Functional Entity Mobility Context Transfer

- FE_I: Functional Entity Ingress to DMM plane

- FE_E: Functional Entity Egress of DMM plane

- FE_IEC: Functional Entity for Ingress/Egress Control

The list comprises a generic router/switch function FE_R that's supposed to build the transport network. It has no particular function that's specific to DMM, but performs routing according to a longest prefix match. Deployment specific aspects, such as the use of IP/MPLS, are not (yet) considered in this draft.

The entity FE_MA represents an unmodified function of the mobility architecture's mobility anchor. In Mobile IPv6, this function would be co-located with the Home Agent, in Proxy Mobile IPv6, this function would be co-located with the Local Mobility Anchor (LMA). In a cellular IP (CIP) enabled domain, this function would be co-located with the domain's CIP Gateway.

The task of the FE_MCTX is to export relevant binding cache information, such as the mobile node's HoA or HNP, from the mobile node's previous mobility anchor (pMA) during mobility anchor relocation to enable IP address continuity after mobility anchor relocation. Furthermore, the function allows importing mobility context on the mobile node's new mobility anchor. Imported HoA/HNP

of a mobile node will be treated as identifier and non-routable IP address (prefix), as it probably does not match the new mobility anchor's location in the topology. Furthermore, the FE_MCTX can provide mobility context to the FE_IEC to allow keeping these policies updated, which allow forwarding of packets to the MN's currently used mobility anchor.

The function FE_I enables deviations from the standard routing path of the mobile node's downlink packets, which carry the mobile node's HoA/HNP in the destination IP address field of their IP header. Uplink packets are currently assumed to be routable, as the mobile node's topologically incorrect IP address (prefix) is carried in the source address field. No filtering according to source addresses is currently considered. The FE_I can retrieve information from a control function (FE_IEC) to establish forwarding of the mobile node's packets to the appropriate DMM egress function (FE_E). Forwarding can be for example accomplished by an IP tunnel to the egress function, address translation to a routable IP address or other means.

The function FE_E receives downlink packets being forwarded by the DMM ingress function FE_I, e.g. by terminating a forwarding tunnel. The state on the FE_I can be established through the DMM ingress/ egress control function (FE_IEC) and is used to identify an MN's received packets and deliver them to the MN's current mobility anchor (FE_MA). If the FE_E is co-located with the FE_MA, the delivery is a local operation. If the FE_E is not co-located with the FE_MA, other techniques, such as host-routes or technology such as OpenFlow may be used to deliver the packets to the mobile node's current mobility anchor. If not co-located with the FE_MA, the FE_E is supposed to be located close to the mobile node's current FE_MA.

The function FE_IEC represents a control function, that establishes, updates and removes policies (per-host or grouped) in the FE_I and the FE_E to allow forwarding of a mobile node's downlink packets towards the mobile node's current mobility anchor.

```
                Control Plane:        :        Data Plane:
                                      :
                                      :         |data packet
                                      :         v for mobile node
              +----+      R_IC        :      +----+
              |FE_I|<----------+      :      |FE_I|
              +----+           |      :      +----+
                          +--+ |      :         |
                      R_II|  | |      :         |
                          v  v v      :         |
                         +------+     :         |
                         |FE_IEC|     :         |
                         +------+     :         |
                           ^  ^       :         v
              +----+       |  |       :      +----+
              |FE_E|<------+  |R_XC   :      |FE_E|
              +----+  R_EC    |       :      +----+
                              v       :         |
                           +-------+  :         |
                           |FE_MCTX|  :         |
                           +-------+  :         |
                            ^  ^  ^   :         v
              +-----+       |  |  |   :      +-----+
              |FE_MA|<------+  +--+   :      |FE_MA|
              +-----+  R_XA    R_XX   :      +-----+
```

Figure 1: Basic set of functional entities (FE) and interfaces to enable IP-address continuity in DMM

The reference points between FEs comprise the following features:

- o R_XA: Enables the FE_MCTX to retrieve mobility context information from the FE_MA of the MN's mobility anchor. Such information includes for example the MN's Home Address (HoA) or Home Network Prefix (HNP). In the network of the MN's new mobility anchor, the reference point enables the FE_MCTX to provide the MN's mobility context to the associated FE_MA, that imports the MN's mobility context to enable IP address continuity.

- o R_XX: Enables the direct transfer of an MN's mobility context between two functions FE_MCTX, which are typically located in the network of the MN's previous and new mobility anchor respectively.

- o R_IC: Enables the FE_IEC to provide policies to the FE_I, which are used to forward the MN's downlink packets towards the MN's new mobility anchor and the associated FE_E. These policies can be provided to the FE_I in an unsolicited manner or on request by the

FE_I.

- R_EC: Enables the FE_IEC to provide policies to the FE_E, which are used at the FE_E to identify received packets that belong to a particular MN and deliver these packets to the MN's new mobility anchor. Such policies could include, for example, tunnel endpoint information, flow identification rules or other identification and addressing rules.

- R_XC: Enables initialization and update of the FE_IEC about the MN's mobility context as well as about its current location as represented by the FE_E in the network of the MN's current mobility anchor.

- R_II: Multiple instances of an FE_IEC can be deployed to build a DMM architecture, e.g. to distribute load and scale better, or distribute tasks associated with the FE_IEC to enable cooperative solutions.

4. Different Constellations of Functional Entities

The defined FEs can be grouped or distributed to build a DMM architecture that considers new architecture components or that is based on components of existing protocols. As a starting point, this section depicts and describes two deployment variants, which reflect the current understanding of the WG how DMM could be accomplished using existing protocol specifications as base. Variants of these two deployment models or entirely new models are possible and can be added to future versions of this document.

Note: This section is incomplete and needs further input on different deployment models and variants.

4.1. Condensed Deployment: Mobility Anchor Centric Solutions

Mobility Anchor centric solutions aim at extensions to available mobility protocols to enable DMM, without being dependent on any external, non-mobility component and protocol. IP address continuity is typically established on the control plane by extensions to the mobility protocol to convey an MN's mobility context to a new mobility anchor, and on the data plane by the establishment of a forwarding tunnel between mobility anchors to deliver downlink packets from the originally assigned mobility anchor to the MN's currently used mobility anchor after anchor relocation.

```
               |data destined
               v to mobile node (MN)
             +----+
             |FE_R|
             +----+
               |
               |
               |
               |
               |
               |
           +---v--------------+                 +------------------+
           | +----+           |                 | +----+           |
           | |FE_I|--==========================-->|FE_E|           |
           | +----+           |                 | +----+           |
           |        +------+  |                 |   |    +------+  |
           |        |FE_IEC|  |                 |   |    |FE_IEC|  |
           |        +------+  |                 |   |    +------+  |
           |                  |                 |   |              |
           |        +-------+ |                 |   |    +-------+ |
           |        |FE_MCTX| |                 |   |    |FE_MCTX| |
           |        +-------+ |                 |   v    +-------+ |
           | +-----+          |                 | +-----+          |
           | |FE_MA|          |                 | |FE_MA|          |
           | +-----+          |                 | +-----+          |
           +------------------+                 +---|--------------+
             MN's previous MA                       |  MN's current MA
                                                    v
                                                   +--+
                                                   |MN|
                                                   +--+
```

Figure 2: Condensed Deployment: Mobility Anchor Centric Solutions

4.2. Cooperative Deployment: Distributed Architecture

A distributed architecture considers protocol operation between distributed FEs, aiming at a DMM solution that's to a large extent independent of the mobility architecture and protocol. A further goal is to establish optimal routing paths for the MN's traffic after the MN's mobility anchor has been relocated and IP address continuity must be provided.

```
                  |data destined
                  v to mobile node (MN)
                +----+
                |FE_R|
                +----+
                  |
                  v
                +----+
                |FE_I|----------------------------------------+
                +----+                                        |
                                    +------+                  |
                                    |FE_IEC|                  |
                                    +------+                  |
                                                              |
              +------------------+             +--------------v----+
              |        +-------+ |             | +-------+  +----+ |
              |        |FE_MCTX| |             | |FE_MCTX|  |FE_E| |
              |        +-------+ |             | +-------+  +----+ |
              | +-----+          |             |              |    |
              | |FE_MA|          |             |           +-----+ |
              | +-----+          |             |           |FE_MA| |
              +------------------+             |           +-----+ |
                  MN's previous                +--------------|----+
                  mobility                      MN's current  v
                  anchor                        mobility    +--+
                                                anchor      |MN|
                                                            +--+
```

Figure 3: Cooperative Deployment: Distributed Architecture

5. Analysis of enabling technology according to different deployment models

Note: This section is incomplete. A Gap analysis can be performed based on input from Section 4 about different deployment models and variants. A reasonable set of models can be mapped to the architecture of existing protocols from within or beyond the IP mobility protocol solution space.

6. Security Considerations

Different constellations of Functional Entities may allow re-use of existing protocols' security mechanisms to protect DMM protocol operation. In particular in a distributed model, new interfaces must be protected, e.g. to counteract unauthorized packet redirection to a different, possibly malicious mobility anchor. Details about security threats will be studied when the placement of Functional Entities for a selected set of preferred deployment models becomes mature.

7. IANA Considerations

As this document represents a framework and no protocol specification, there is no need for IANA actions.

8. Normative References

[I-D.ietf-dmm-requirements]
Chan, A., "Requirements for Distributed Mobility Management", draft-ietf-dmm-requirements-02 (work in progress), September 2012.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

Author's Address

Marco Liebsch
NEC Laboratories Europe
NEC Europe Ltd.
Kurfuersten-Anlage 36
D-69115 Heidelberg,
Germany

Phone: +49 6221 4342146
Email: liebsch@neclab.eu