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Distributed Mobility Management: Current practices and gap analysis  
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## Abstract

The present document analyzes deployment practices of existing IP mobility protocols in a distributed mobility management environment. It then identifies existing limitations when compared to the requirements defined for a distributed mobility management solution.

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## 1. Introduction

The distributed mobility management (DMM) WG has studied the problems of centralized deployment of mobility management protocols and specified the DMM requirements [I-D.ietf-dmm-requirements]. This document investigates whether it is feasible to deploy current IP mobility protocols in a DMM scenario in a way that can fulfill the requirements. It discusses current deployment practices of existing mobility protocols in a distributed mobility management environment and identifies the limitations (gaps) in these practices with respect to the DMM functionality, as defined in [I-D.ietf-dmm-requirements].

The rest of this document is organized as follows. Section 3 analyzes existing IP mobility protocols by examining their functions

and how these functions can be configured and used to work in a DMM environment. Section 4 presents the current practices of IP flat wireless networks and 3GPP architectures. Both network- and host-based mobility protocols are considered. Section 5 presents the gap analysis with respect to the current practices.

## 2. 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].

All general mobility-related terms and their acronyms used in this document are to be interpreted as defined in the Mobile IPv6 base specification [RFC6275] and in the Proxy mobile IPv6 specification [RFC5213]. These terms include mobile node (MN), correspondent node (CN), home agent (HA), local mobility anchor (LMA), and mobile access gateway (MAG).

In addition, this document also introduces some definitions of IP mobility functions in Section 3.

In this document there are also references to a "distributed mobility management environment". By this term, we refer to a scenario in which the IP mobility, access network and routing solutions allow for setting up IP networks so that traffic is distributed in an optimal way, without relying on centrally deployed anchors to manage IP mobility sessions.

## 3. Functions of existing mobility protocols

The host-based Mobile IPv6 [RFC6275] and its network-based extension, PMIPv6 [RFC5213], are both logically centralized mobility management approaches addressing primarily hierarchical mobile networks. Although they are centralized approaches, they have important mobility management functions resulting from years of extensive work to develop and to extend these functions. It is therefore useful to take these existing functions and examine them in a DMM scenario in order to understand how to deploy the existing mobility protocols in a distributed mobility management environment.

The main mobility management functions of MIPv6, PMIPv6, and HMIPv6 are the following:

1. Anchoring function (AF): allocation to a mobile node of an IP address/prefix (e.g., a Home Address or Home Network Prefix) topologically anchored by the delegating node (i.e., the anchor node is able to advertise a connected route into the routing

infrastructure for the delegated IP prefixes). It is a control plane function.

2. Internetwork Location Management (LM) function: managing and keeping track of the internetwork location of an MN. The location information may be a mapping of the IP delegated address /prefix (e.g., HoA or HNP) to the IP routing address of the MN or of a node that can forward packets destined to the MN. It is a control plane function.

In a client-server model of the system, location query and update messages may be exchanged between the client (LMc) and the server (LMs).

Optionally, one (or more) proxy may exist between the LMs and the LMc, i.e., LMs-proxy-LMc. Then, to the LMs, the proxy behaves like the LMc; to the LMc, the proxy behaves like the LMs.

3. Routing management (RM) function: packet interception and forwarding to/from the IP address/prefix delegated to the MN, based on the internetwork location information, either to the destination or to some other network element that knows how to forward the packets to their destination.

RM may optionally be split into the control plane (RM-CP) and data plane (RM-DP).

In Mobile IPv6 [RFC6275], the home agent (HA) typically provides the anchoring function (AF); the location management server (LMs) is at the HA while the location management client (LMc) is at the MN; the routing management (RM) function is both ends of tunneling at the HA and the MN.

In Proxy Mobile IPv6 [RFC5213], the Local Mobility Anchor (LMA) provides the anchoring function (AF); the location management server (LMs) is at the LMA while the location management client (LMc) is at the mobile access gateway (MAG); the routing management (RM) function is both ends of tunneling at the HA and the MAG.

In Hierarchical mobile IPv6 (HMIPv6) [RFC5380], a location management proxy is at the mobility anchor point (MAP) to proxy between the LMs at the LMA and the LMc at the MN. The MAP also has RM function to enable tunneling between LMA and itself as well as tunneling between MN and itself.

#### 4. DMM practices

This section documents deployment practices of existing mobility protocols in a distributed mobility management environment. This description is divided into two main families of network architectures: i) IP flat wireless networks (e.g., evolved Wi-Fi hotspots) and, ii) 3GPP network flattening approaches.

While describing the current DMM practices, references to the generic mobility management functions described in Section 3 are provided, as well as some initial hints on the identified gaps with respect to the DMM requirements documented in [I-D.ietf-dmm-requirements].

##### 4.1. Assumptions

There are many different approaches that can be considered to implement and deploy a distributed anchoring and mobility solution. The focus of the gap analysis is on current mobile network architectures and standardized IP mobility solutions, considering any kind of deployment options which do not violate the original protocol specifications. In order to limit the scope of our analysis of current DMM practices, we consider the following list of technical assumptions:

1. Both host- and network-based solutions SHOULD be considered.
2. Solutions SHOULD allow selecting and using the most appropriate IP anchor among a set of available ones.
3. Mobility management SHOULD be realized by the preservation of the IP address across the different points of attachment (i.e., provision of IP address continuity).

Applications which can cope with changes in the MN's IP address do not depend on IP mobility management protocols such as DMM. Typically, a connection manager together with the operating system will configure the source address selection mechanism of the IP stack. This might involve identifying application capabilities and triggering the mobility support accordingly. Further considerations on application management and source address selection are out of the scope of this document.

##### 4.2. IP flat wireless network

This section focuses on common IP wireless network architectures and how they can be flattened from an IP mobility and anchoring point of view using common and standardized protocols. We take Wi-Fi as an exemplary wireless technology, since it is widely known and deployed

nowadays. Some representative examples of Wi-Fi deployment architectures are depicted in Figure 1.

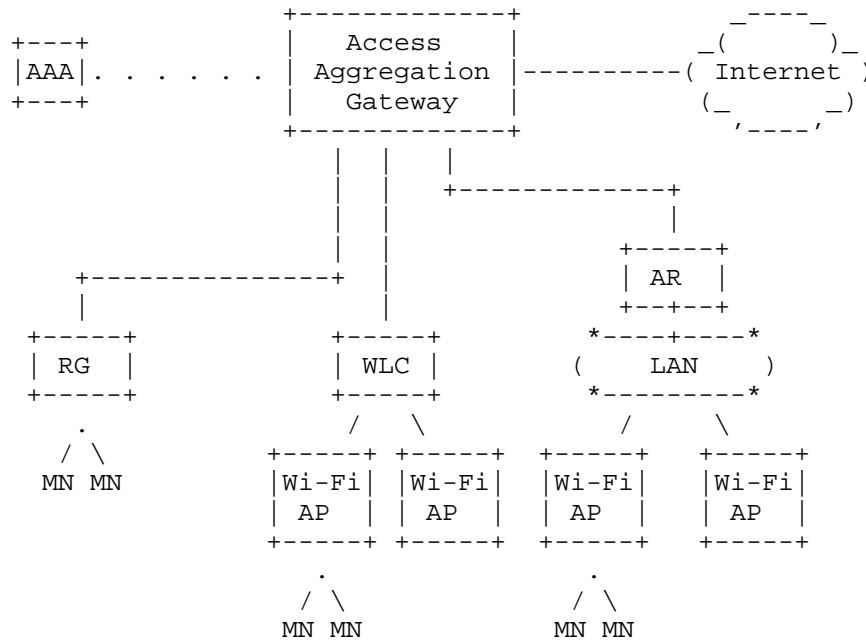


Figure 1: IP Wi-Fi network architectures

In the figure, three typical deployment options are shown [I-D.gundavelli-v6ops-community-wifi-svcs]. On the left hand side of the figure, mobile nodes directly connect to a Residential Gateway (RG) which is a network device at the customer premises and provides both wireless layer-2 access connectivity (i.e., it hosts the 802.11 Access Point function) and layer-3 routing functions. In the middle of the figure, mobile nodes connect to Wi-Fi Access Points (APs) that are managed by a WLAN Controller (WLC), which performs radio resource management on the APs, system-wide mobility policy enforcement and centralized forwarding function for the user traffic. The WLC could also implement layer-3 routing functions, or attach to an access router (AR). Last, on the right-hand side of the figure, access points are directly connected to an access router. This can also be used as a generic connectivity model.

In some network architectures, such as the evolved Wi-Fi hotspot, operators might make use of IP mobility protocols to provide mobility support to users, for example to allow connecting the IP Wi-Fi network to a mobile operator core and support roaming between WLAN and 3GPP accesses. Two main protocols can be used: Proxy Mobile IPv6

[RFC5213] or Mobile IPv6 [RFC6275], [RFC5555], with the anchor (e.g., local mobility anchor or home agent) role typically being played by the Access Aggregation Gateway or even by an entity placed in the mobile operator's core network.

Although this section has adopted the example of Wi-Fi networks, there are other IP flat wireless network architectures specified, such as WiMAX [IEEE.802-16.2009], which integrates both host and network-based IP mobility functionality.

Existing IP mobility protocols can also be deployed in a more flattened manner, so that the anchoring and access aggregation functions are distributed. We next describe several practices for the deployment of existing mobility protocols in a distributed mobility management environment. The analysis in this section is limited to protocol solutions based on existing IP mobility protocols, either host- or network-based, such as Mobile IPv6 [RFC6275], [RFC5555], Proxy Mobile IPv6 [RFC5213], [RFC5844] and NEMO [RFC3963]. Extensions to these base protocol solutions are also considered. We pay special attention to how to efficiently select the source address (care-of-addresses versus home addresses) for different types of communications. The analysis is divided into two parts: host- and network-based practices.

#### 4.2.1. Host-based IP DMM practices

Mobile IPv6 (MIPv6) [RFC6275] and its extension to support mobile networks, the NEMO Basic Support protocol (hereafter, simply referred to as NEMO) [RFC3963] are well-known host-based IP mobility protocols. They heavily rely on the function of the Home Agent (HA), a centralized anchor, to provide mobile nodes (hosts and routers) with mobility support. In these approaches, the home agent typically provides the anchoring function (AF), Routing management (RM), and Internetwork Location Management server (LMs) functions. The mobile node possesses the Location management client (LMc) function and the RM function to enable tunneling between HA and itself. We next describe some practices on how MIPv6/NEMO and several additional protocol extensions can be deployed in a distributed mobility management environment.

One approach to distribute the anchors can be to deploy several HAS (as shown in Figure 2), and assign the topologically closest anchor to each MN [RFC4640], [RFC5026], [RFC6611]. In the example shown in Figure 2, MN1 is assigned HA1 (and a home address anchored by HA1), while MN2 is assigned HA2. Note that MIPv6/NEMO specifications do not prevent the simultaneous use of multiple home agents by a single mobile node. This deployment model could be exploited by a mobile node to meet assumption #4 of Section 4.1 and use several anchors at

the same time, each of them anchoring IP flows initiated at a different point of attachment. However there is no mechanism specified by IETF to enable an efficient dynamic discovery of available anchors and the selection of the most suitable one. Note that some of these mechanisms have been defined outside IETF (e.g., 3GPP).

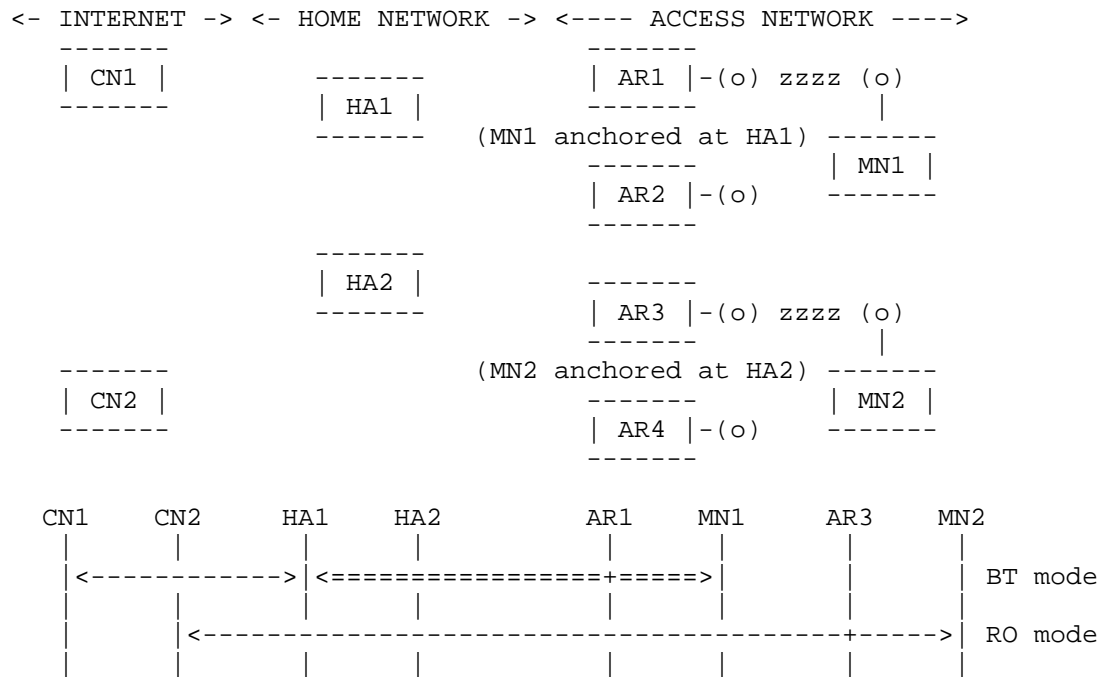


Figure 2: Distributed operation of Mobile IPv6 (BT and RO) / NEMO

Since one of the goals of the deployment of mobility protocols in a distributed mobility management environment is to avoid the suboptimal routing caused by centralized anchoring, the Route Optimization (RO) support provided by Mobile IPv6 can also be used to achieve a flatter IP data forwarding. By default, Mobile IPv6 and NEMO use the so-called Bidirectional Tunnel (BT) mode, in which data traffic is always encapsulated between the MN and its HA before being directed to any other destination. The Route Optimization (RO) mode allows the MN to update its current location on the CNs, and then use the direct path between them. Using the example shown in Figure 2, MN1 is using BT mode with CN1 and MN2 is in RO mode with CN2. However, the RO mode has several drawbacks:

- o The RO mode is only supported by Mobile IPv6. There is no route optimization support standardized for the NEMO protocol because of

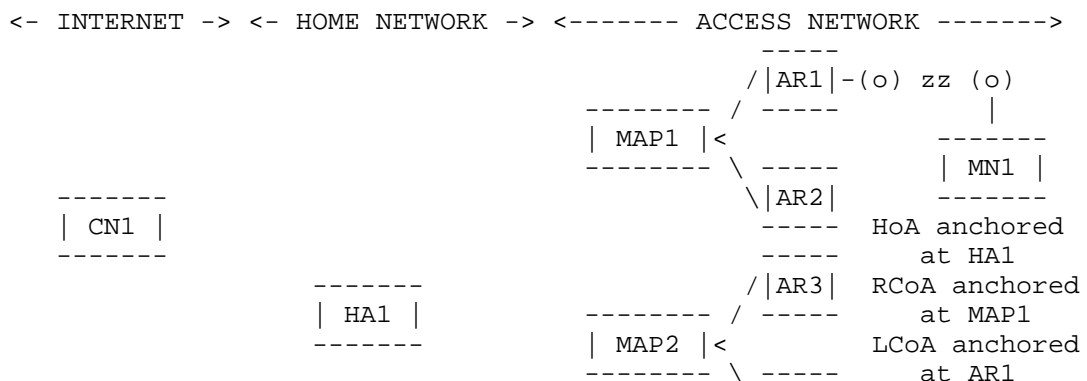


the security problems posed by extending return routability tests for prefixes, although many different solutions have been proposed [RFC4889].

- o The RO mode requires additional signaling, which adds some protocol overhead.
- o The signaling required to enable RO involves the home agent and is repeated periodically for security reasons [RFC4225]. This basically means that the HA remains a single point of failure, because the Mobile IPv6 RO mode does not mean HA-less operation.
- o The RO mode requires additional support from the correspondent node (CN).

Notwithstanding these considerations, the RO mode does offer the possibility of substantially reducing traffic through the Home Agent, in cases when it can be supported by the relevant correspondent nodes. Note that a mobile node can also use its CoA directly [RFC5014] when communicating with CNs on the same link or anywhere in the Internet, although no session continuity support would be provided by the IP stack in this case.

Hierarchical Mobile IPv6 (HMIPv6) [RFC5380] (as shown in Figure 3), is another host-based IP mobility extension which can be considered as a complement to provide a less centralized mobility deployment. It allows reducing the amount of mobility signaling as well as improving the overall handover performance of Mobile IPv6 by introducing a new hierarchy level to handle local mobility. The Mobility Anchor Point (MAP) entity is introduced as a local mobility handling node deployed closer to the mobile node. It provides LM proxy function between the LM server (LMs) at the HA and the LM client (LMc) at the MN. It also possess RM function to tunnel with the HA and also to tunnel with the MN.



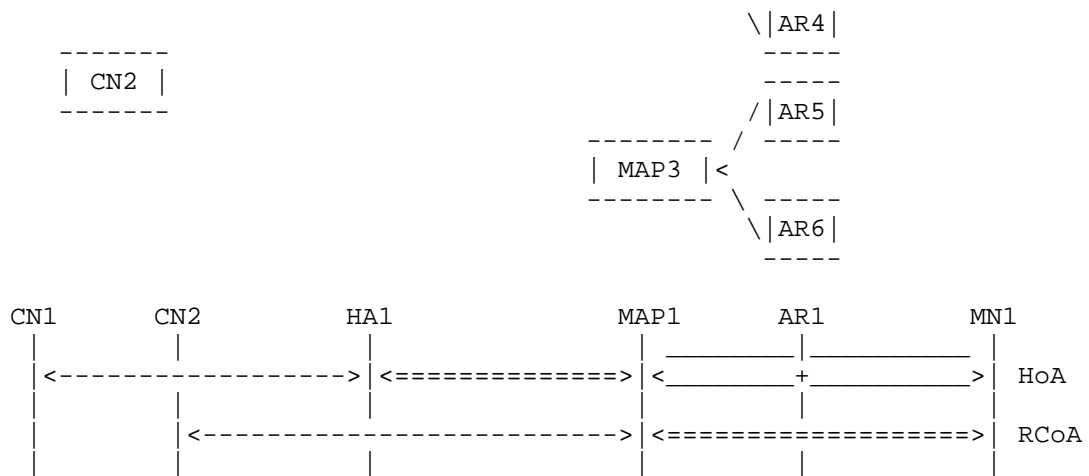


Figure 3: Hierarchical Mobile IPv6

When HMIPv6 is used, the MN has two different temporal addresses: the Regional Care-of Address (RCoA) and the Local Care-of Address (LCoA). The RCoA is anchored at one MAP, that plays the role of local home agent, while the LCoA is anchored at the access router level. The mobile node uses the RCoA as the CoA signaled to its home agent. Therefore, while roaming within a local domain handled by the same MAP, the mobile node does not need to update its home agent (i.e., the mobile node does not change its RCoA).

The use of HMIPv6 allows achieving some form of route optimization, since a mobile node may decide to directly use the RCoA as source address for a communication with a given correspondent node, notably if the MN does not expect to move outside the local domain during the lifetime of the communication. This can be seen as a potential DMM mode of operation. In the example shown in Figure 3, MN1 is using its global HoA to communicate with CN1, while it is using its RCoA to communicate with CN2.

Additionally, a local domain might have several MAPs deployed, enabling therefore a different kind of HMIPv6 deployments (e.g., flat and distributed). The HMIPv6 specification supports a flexible selection of the MAP (e.g., based on the distance between the MN and the MAP, taking into consideration the expected mobility pattern of the MN, etc.).

An additional extension that can be used to help deploying a mobility protocol in a distributed mobility management environment is the Home Agent switch specification [RFC5142], which defines a new mobility header for signaling a mobile node that it should acquire a new home

agent. Even though the purposes of this specification do not include the case of changing the mobile node's home address, as that might imply loss of connectivity for ongoing persistent connections, it could be used to force the change of home agent in those situations where there are no active persistent data sessions that cannot cope with a change of home address.

There are other host-based approaches standardized within IETF that can be used to provide mobility support. For example MOBIKE [RFC4555] allows a mobile node encrypting traffic through IKEv2 [RFC5996] to change its point of attachment while maintaining a Virtual Private Network (VPN) session. The MOBIKE protocol allows updating the VPN Security Associations (SAs) in cases where the base connection initially used is lost and needs to be re-established. The use of the MOBIKE protocol avoids having to perform an IKEv2 re-negotiation. Similar considerations to those made for Mobile IPv6 can be applied to MOBIKE; though MOBIKE is best suited for situations where the address of at least one endpoint is relatively stable and can be discovered using existing mechanisms such as DNS.

#### 4.2.2. Network-based IP DMM practices

Proxy Mobile IPv6 (PMIPv6) [RFC5213] is the main network-based IP mobility protocol specified for IPv6 ([RFC5844] defines some IPv4 extensions). With network-based IP mobility protocols, the local mobility anchor (LMA) typically provides the anchoring function (AF), Routing management (RM) function, Internetwork Location Management server (LMs) function and RM function. The mobile access gateway (MAG) provides the Location Management client (LMc) function and Routing management (RM) function to tunnel with LMA. PMIPv6 is architecturally similar to MIPv6, as the mobility signaling and routing between LMA and MAG in PMIPv6 is similar to those between HA and MN in MIPv6. The required mobility functionality at the MN is provided by the MAG so that the involvement in mobility support by the MN is not required.

We next describe some practices on how network-based mobility protocols and several additional protocol extensions can be deployed in a distributed mobility management environment.

One simple but still suboptimal approach to decentralize Proxy Mobile IPv6 operation can be to deploy several local mobility anchors and use some selection criteria to assign LMAs to attaching mobile nodes (an example of this type of assignment is shown in Figure 4). As per the client based approach, a mobile node may use several anchors at the same time, each of them anchoring IP flows initiated at a different point of attachment. This assignment can be static or dynamic (as described later in this document). The main advantage of

this simple approach is that the IP address anchor (i.e., the LMA) could be placed closer to the mobile node. Therefore the resulting paths are close-to-optimal. On the other hand, as soon as the mobile node moves, the resulting path will start deviating from the optimal one.

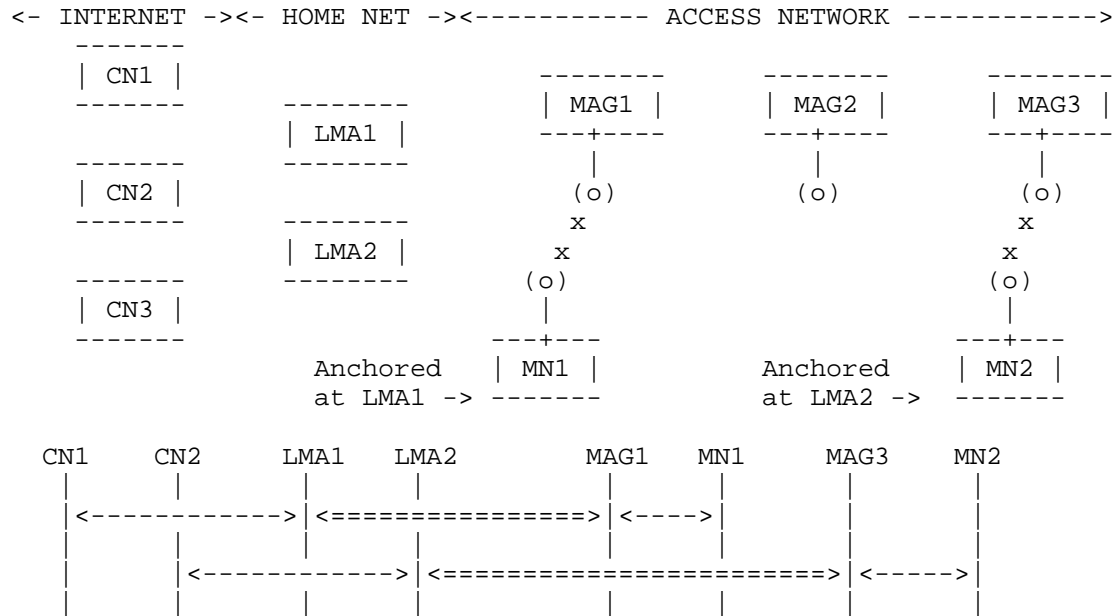


Figure 4: Distributed operation of Proxy Mobile IPv6

Similar to the host-based IP mobility case, network-based IP mobility has some extensions defined to mitigate the suboptimal routing issues that may arise due to the use of a centralized anchor. The Local Routing extensions [RFC6705] enable optimal routing in Proxy Mobile IPv6 in three cases: i) when two communicating MNs are attached to the same MAG and LMA, ii) when two communicating MNs are attached to different MAGs but to the same LMA, and iii) when two communicating MNs are attached to the same MAG but have different LMAs. In these three cases, data traffic between the two mobile nodes does not traverse the LMA(s), thus providing some form of path optimization since the traffic is locally routed at the edge. The main disadvantage of this approach is that it only tackles the MN-to-MN communication scenario, and only under certain circumstances.

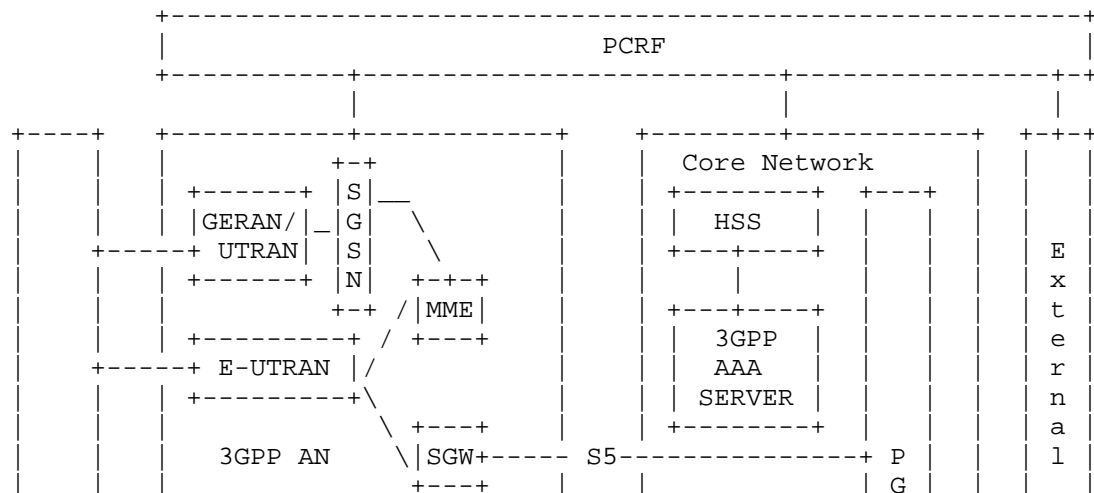
An interesting extension that can also be used to facilitate the deployment of network-based mobility protocols in a distributed mobility management environment is the LMA runtime assignment [RFC6463]. This extension specifies a runtime local mobility anchor

assignment functionality and corresponding mobility options for Proxy Mobile IPv6. This runtime local mobility anchor assignment takes place during the Proxy Binding Update / Proxy Binding Acknowledgment message exchange between a mobile access gateway and a local mobility anchor. While this mechanism is mainly aimed for load-balancing purposes, it can also be used to select an optimal LMA from the routing point of view. A runtime LMA assignment can be used to change the assigned LMA of an MN, for example, in cases when the mobile node does not have any active session, or when the running sessions can survive an IP address change. Note that several possible dynamic local mobility anchor discovery solutions can be used, as described in [RFC6097].

#### 4.3. 3GPP network flattening approaches

The 3rd Generation Partnership Project (3GPP) is the standards development organization that specifies the 3rd generation mobile network and the Evolved Packet System (EPS), which mainly comprises the Evolved Packet Core (EPC) and a new radio access network, sometimes referred to as LTE (Long Term Evolution).

Architecturally, the 3GPP Evolved Packet Core (EPC) network is similar to an IP wireless network running PMIPv6 or MIPv6, as it relies on the Packet Data Gateway (PGW) anchoring services to provide mobile nodes with mobility support (see Figure 5). There are client-based and network-based mobility solutions in 3GPP, which for simplicity will be analyzed together. We next describe how 3GPP mobility protocols and several additional completed or ongoing extensions can be deployed to meet some of the DMM requirements [I-D.ietf-dmm-requirements].



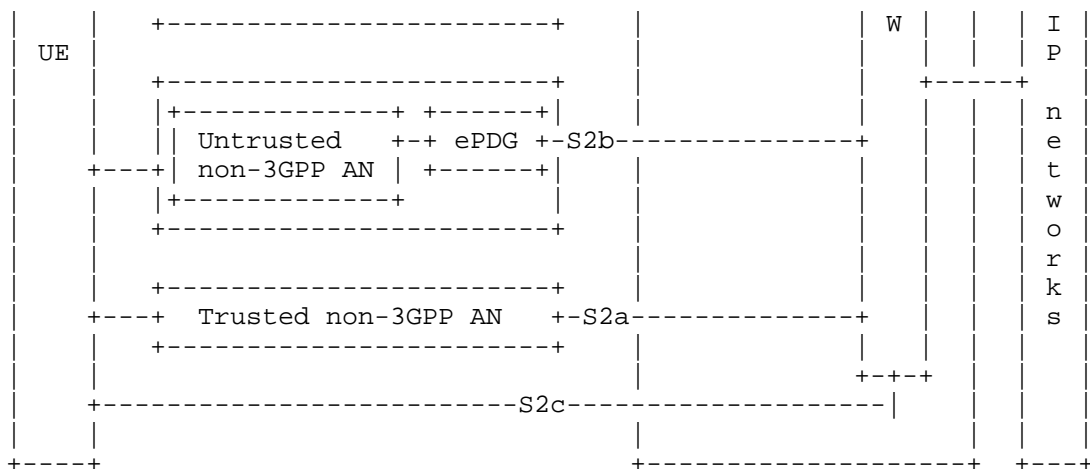
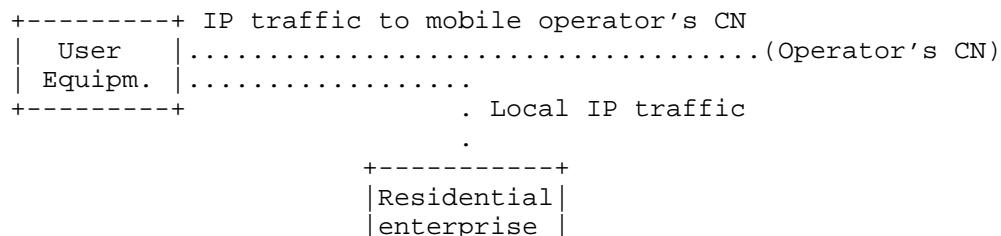


Figure 5: EPS (non-roaming) architecture overview

The GPRS Tunnelling Protocol (GTP) [SDO-3GPP.29.060] [SDO-3GPP.29.281] [SDO-3GPP.29.274] is a network-based mobility protocol specified for 3GPP networks (S2a, S2b, S5 and S8 interfaces). Similar to PMIPv6, it can handle mobility without requiring the involvement of the mobile nodes. In this case, the mobile node functionality is provided in a proxy manner by the Serving Data Gateway (SGW), Evolved Packet Data Gateway (ePDG), or Trusted Wireless Access Gateway (TWAG).

3GPP specifications also include client-based mobility support, based on adopting the use of Dual-Stack Mobile IPv6 (DSMIPv6) [RFC5555] for the S2c interface. In this case, the User Equipment (UE) implements the mobile node functionality, while the home agent role is played by the PGW.

A Local IP Access (LIPA) and Selected IP Traffic Offload (SIPTO) enabled network [SDO-3GPP.23.401] allows offloading some IP services at the local access network, above the Radio Access Network (RAN) or at the macro, without the need to traverse back to the PGW (see Figure 6).



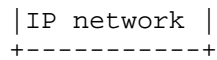


Figure 6: LIPA scenario

SIPTO enables an operator to offload certain types of traffic at a network node close to the UE's point of attachment to the access network, by selecting a set of GWs (SGW and PGW) that are geographically/topologically close to the UE's point of attachment.

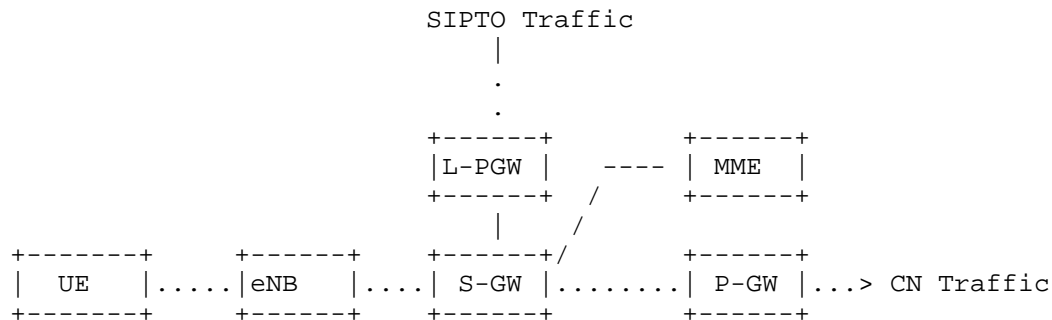


Figure 7: SIPTO architecture

LIPA, on the other hand, enables an IP capable UE connected via a Home eNB (HeNB) to access other IP capable entities in the same residential/enterprise IP network without traversing the mobile operator's network core in the user plane. In order to achieve this, a Local GW (L-GW) collocated with the HeNB is used. LIPA is established by the UE requesting a new PDN connection to an access point name for which LIPA is permitted, and the network selecting the Local GW associated with the HeNB and enabling a direct user plane path between the Local GW and the HeNB.

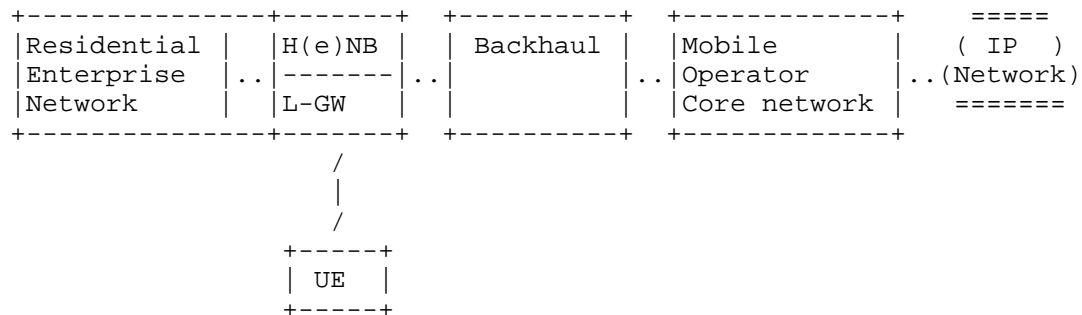


Figure 8: LIPA architecture

The 3GPP architecture specifications also provide mechanisms to allow discovery and selection of gateways [SDO-3GPP.29.303]. These mechanisms enable decisions taking into consideration topological location and gateway collocation aspects, using heavily the DNS as a "location database".

Both SIPTO and LIPA have a very limited mobility support, specially in 3GPP specifications up to Rel-12. In a glimpse, LIPA mobility support is limited to handovers between HeNBs that are managed by the same L-GW (i.e., mobility within the local domain), while seamless SIPTO mobility is still limited to the case where the SGW/PGW is at or above Radio Access Network (RAN) level.

## 5. Gap analysis

The goal of this section is to identify the limitations in the current practices, described in Section 4, with respect to the DMM requirements listed in [I-D.ietf-dmm-requirements].

### 5.1. Distributed processing - REQ1

According to requirement #1 stated in [I-D.ietf-dmm-requirements], IP mobility, network access and routing solutions provided by DMM MUST enable distributed processing for mobility management so that traffic can avoid traversing single mobility anchor far from the optimal route.

From the analysis performed in Section 4, a DMM deployment can meet the requirement "REQ#1 Distributed processing" usually relying on the following functions:

- o Multiple (distributed) anchoring: ability to anchor different sessions of a single mobile node at different anchors. In order to make this feature "DMM-friendly", some anchors might need to be placed closer to the mobile node.
- o Dynamic anchor assignment/re-location: ability to i) optimally assign initial anchor, and ii) dynamically change the initially assigned anchor and/or assign a new one (this may also require to transfer mobility context between anchors). This can be achieved either by changing anchor for all ongoing sessions, or by assigning new anchors just for new sessions.

Both the main client- and network-based IP mobility protocols, namely (DS)MIPv6 and PMIPv6 allow deploying multiple anchors (i.e., home agents and localized mobility anchors), therefore providing the multiple anchoring function. However, existing solutions only provide an optimal initial anchor assignment, thus the lack of



dynamic anchor change/new anchor assignment is a gap. Neither the HA switch nor the LMA runtime assignment allow changing the anchor during an ongoing session. This actually comprises several gaps: ability to perform anchor assignment at any time (not only at the initial MN's attachment), ability of the current anchor to initiate/trigger the relocation, and ability to transfer registration context between anchors.

Dynamic anchor assignment may lead the MN to manage different mobility sessions served by different mobility anchors. This is not an issue with client based mobility management where the mobility client natively knows each anchor associated to each mobility sessions. However, there is one gap, as the MN should be capable of handling IP addresses in a DMM-friendly way, meaning that the MN can perform smart source address selection (i.e., deprecating IP addresses from previous mobility anchors, so they are not used for new sessions). Besides, managing different mobility sessions served by different mobility anchors may raise issues with network based mobility management. In this case, the mobile client, located in the network (e.g., MAG), usually retrieves the MN's anchor from the MN's policy profile (e.g., Section 6.2 of [RFC5213]). Currently, the MN's policy profile implicitly assumes a single serving anchor and, thus, does not maintain the association between home network prefix and anchor.

The consequence of the distribution of the mobility anchors is that there might be more than one available anchor for a mobile node to use, which leads to an anchor discovery and selection issue. Currently, there is no efficient mechanism specified by IETF to allow dynamically discovering the presence of nodes that can play the anchor role, discovering their capabilities and selecting the most suitable one. There is also no mechanism to allow selecting a node that is currently anchoring a given home address/prefix (capability sometimes required to meet REQ#2). There are though some mechanisms that could help discovering anchors, such as the Dynamic Home Agent Address Discovery (DHAAD), the use of the Home Agent (H) flag in Router Advertisements (which indicates that the router sending the Router Advertisement is also functioning as a Mobile IPv6 home agent on the link) or the MAP option in Router Advertisements defined by HMIPv6. Note that there are 3GPP mechanisms providing that functionality defined in [SDO-3GPP.29.303].

Also note that REQ1 is such that the data plane traffic can avoid suboptimal route. Distributed processing of the traffic is then needed only in the data plane. The needed capability in distributed processing therefore should not contradict with centralized control plane. Other control plane solutions such as charging, lawful interception, etc. should not be limited. Yet combining the control

plane and data plane routing management (RM) function may limit the choice to distributing both data plane and control plane together. In order to enable distributing only the data plane without distributing the control plane, a gap is to split the routing management function into the control plane (RM-CP) and data plane (RM-DP).

## 5.2. Bypassable network-layer mobility support - REQ2

The need for "bypassable network-layer mobility support" introduced in [I-D.ietf-dmm-requirements] will enable dynamic mobility management. Note that this requirement is not on dynamic mobility itself but only enables it. It therefore leaves flexibility on the determination of whether network-layer mobility support is needed and the role to use or not use network-layer mobility support. The requirement only enables one to use or not use network-layer mobility support. It only enables the which basically leverages the two following functions:

- o Dynamically assign/relocate anchor: a mobility anchor is assigned only to sessions which uses the network-layer mobility support. The MN may thus manage more than one session; some of them may be associated with anchored IP address(es), while the others may be associated with local IP address(es).
- o Multiple IP address management: this function is related to the preceding and is about the ability of the mobile node to simultaneously use multiple IP addresses and select the best one (from an anchoring point of view) to use on a per-session/application/service basis.

The dynamic anchor assignment/relocation needs to ensure that IP address continuity is guaranteed for sessions that uses such mobility support (e.g., in some scenarios, the provision of mobility locally within a limited area might be enough from the mobile node or the application point of view) at the relocated anchor. Implicitly, when no applications are using the network-layer mobility support, DMM may release the needed resources. This may imply having the knowledge of which sessions at the mobile node are active and are using the mobility support. This is something typically known only by the MN (e.g., by its connection manager). Therefore, (part of) this knowledge might need to be transferred to/shared with the network.

Multiple IP address management provides the MN with the choice to pick-up the correct address (provided with mobility support or not) depending on the application requirements. When using client based mobility management, the mobile node is natively aware about the anchoring capabilities of its assigned IP addresses. This is not the

case with network based IP mobility management and current mechanisms does not allow the MN to be aware of the IP addresses properties (i.e., the MN does not know whether the allocated IP addresses are anchored). However, there are ongoing IETF works that are proposing that the network could indicate the different IP addresses properties during assignment procedures, such as [I-D.bhandari-dhc-class-based-prefix], [I-D.korhonen-6man-prefix-properties] and [I-D.anipko-mif-mpvd-arch]. However, although there exist these individual efforts that could be considered as attempts to fix the gap, there is no solution close to be adopted and standardized in IETF.

### 5.3. IPv6 deployment - REQ3

This requirement states that DMM solutions SHOULD primarily target IPv6 as the primary deployment environment. IPv4 support is not considered mandatory and solutions SHOULD NOT be tailored specifically to support IPv4, in particular in situations where private IPv4 addresses and/or NATs are used.

All analyzed DMM practices support IPv6. Some of them, such as MIPv6/NEMO (including the support of dynamic HA selection), MOBIKE, SIPTO have also IPv4 support. Additionally, there are also some solutions that have some limited IPv4 support (e.g., PMIPv6). In conclusion, this requirement is met by existing DMM practices.

### 5.4. Existing mobility protocols - REQ4

A DMM solution MUST first consider reusing and extending IETF-standardized protocols before specifying new protocols.

As stated in [I-D.ietf-dmm-requirements], a DMM solution could reuse existing IETF and standardized protocols before specifying new protocols. Besides, Section 4 of this document discusses various ways to flatten and distribute current mobility solutions. Actually, nothing prevent the distribution of mobility functions with vanilla IP mobility protocols. However, as discussed in Section 5.1 and Section 5.2, limitations exist. The 3GPP data plane anchoring function, i.e., the PGW, can be also be distributed, but with limitations; e.g., no anchoring relocation, no context transfer between anchors, centralized control plane. The 3GPP architecture is also going into the direction of flattening with SIPTO and LIPA, though they do not provide mobility support.

### 5.5. Co-existence - REQ5

According to [I-D.ietf-dmm-requirements], DMM solution MUST be able to co-exist with existing network deployments, end hosts and routers.

All current mobility protocols can co-exist with existing network deployments and end hosts. There is no gap between existing mobility protocols and this requirement.

#### 5.6. Security considerations - REQ6

As stated in [I-D.ietf-dmm-requirements], a DMM solution MUST NOT introduce new security risks, or amplify existing security risks, that cannot be mitigated by existing security mechanisms or protocols. Current mobility protocols have all security mechanisms in place. For example, Mobile IPv6 defines security features to protect binding updates both to home agents and correspondent nodes. It also defines mechanisms to protect the data packets transmission for Mobile IPv6 users. Proxy Mobile IPv6 and other variation of mobile IP also have similar security considerations.

#### 5.7. Multicast - REQ7

It is stated in [I-D.ietf-dmm-requirements] that DMM solutions SHOULD enable multicast solutions to be developed to avoid network inefficiency in multicast traffic delivery.

Current IP mobility solutions address mainly the mobility problem for unicast traffic. Solutions relying on the use of an anchor point for tunneling multicast traffic down to the access router, or to the mobile node, introduce the so-called "tunnel convergence problem". This means that multiple instances of the same multicast traffic can converge to the same node, defeating hence the advantage of using multicast protocols.

The MULTIMOB WG in IETF has studied this issue, for the specific case of PMIPv6, and has produced a baseline solution [RFC6224] as well as a routing optimization solution [RFC7028] to address the problem. The baseline solution suggests deploying an MLD proxy function at the MAG, and either a multicast router or another MLD proxy function at the LMA. The routing optimization solution describes an architecture where a dedicated multicast tree mobility anchor (MTMA) or a direct routing option can be used to avoid the tunnel convergence problem.

Besides the solutions proposed in MULTIMOB for PMIPv6, there are no solutions for other mobility protocols to address the multicast tunnel convergence problem.

## 5.8. Summary

We next list the main gaps identified from the analysis performed above:

- o Existing solutions do only provide an optimal initial anchor assignment, a gap being the lack of dynamic anchor change/new anchor assignment. Neither the HA switch nor the LMA runtime assignment allow changing the anchor during an ongoing session. While MOBIKE could be used to switch from a gateway to another in the middle of a session from MN side, there is no protocol support for the network side.
- o The mobile node needs to simultaneously use multiple IP addresses, which requires additional support which might not be available on the mobile node's stack, especially for the case of network-based solutions.
- o Currently, there is no efficient mechanism specified by the IETF that allows to dynamically discover the presence of nodes that can play the role of anchor, discover their capabilities and allow the selection of the most suitable one. There are though some mechanisms that could help discovering anchors, such as the Dynamic Home Agent Address Discovery (DHAAD), the use of the Home Agent (H) flag in Router Advertisements (which indicates that the router sending the Router Advertisement is also functioning as a Mobile IPv6 home agent on the link) or the MAP option in Router Advertisements defined by HMIPv6.
- o While existing network-based DMM practices may allow to deploy multiple LMAs and dynamically select the best one, this requires to still keep some centralization in the control plane, to access on the policy store (as defined in RFC5213). Currently, there is a lack of solutions/extensions that support a clear control and data plane separation for IETF IP mobility protocols.

## 6. Security Considerations

This document does not define any protocol, so it does not introduce any new security concern.

## 7. IANA Considerations

None.

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Distributed mobility management deployment scenario and architecture  
draft-liu-dmm-deployment-scenario-05

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## Abstract

This document discusses the deployment scenario of distributed mobility management. The purpose of this document is to trigger the discussion in the group to understand the DMM deployment scenario and consideration from the operator's perspective.

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| 1. Introduction   |    |

Distributed mobility management aims at solving the centralized mobility anchor problems of the traditional mobility management protocol. The benefit of DMM solution is that the data plane traffic does not need to traverse the centralized anchoring point. This document discusses the potential deployment scenario of DMM. The purpose of this document is to help the group to reach consensus

regarding the deployment model of DMM and then develop the DMM solution based on the deployment model.

## 2. Conventions used in this document

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

### 2.1. Terminology

All the general mobility-related terms and their acronyms used in this document are to be interpreted as defined in the Mobile IPv6 base specification [RFC6275], in the Proxy mobile IPv6 specification [RFC5213], and in Mobility Related Terminology [RFC3753]. These terms include the following: mobile node (MN), correspondent node (CN), and home agent (HA) as per [RFC6275]; local mobility anchor (LMA) and mobile access gateway (MAG) as per [RFC5213], and context as per [RFC3753].

In addition, this draft introduces the following terms.

Location information (LI) function

is the logical function that manages and keeps track of the internet work location information of a mobile node which may change its IP address as it moves. The information may associate with each session identifier, the IP routing address of the MN, or of a node that can forward packets destined to the MN.

Forwarding management (FM)

is the logical function that intercepts packets to/from the IP address/prefix delegated to a mobile node and forwards them, based on internetwork location information, either directly towards their destination or to some other network element that knows how to forward the packets to their ultimate destination. With data plane and control plane separation, the forwarding management may be separated into a data-plane forwarding management (FM-DP) function and a control-plane forwarding management (FM-CP) function.

## 3. Deployment Scenario and Model of DMM

As discussed in the DMM requirement document, the centralized mobility management has several drawbacks. The main problem of the centralized mobility management protocols is that all the traffic need to anchor to a centralized anchor point. This approach does not

cause any problem in current mobile network deployment but in the scenario that will be discussed later in this document, centralized mobility management protocols will have many drawbacks and it is believed that DMM is more suitable in that scenario.

The main deployment scenario discussed in this document is divided into three scenarios. The first one is the network function virtualization scenario. In this scenario, the mobile core network's control plane function is centralized in the mobile cloud. Apparently, deploying the data plane function also in the same centralized mobile cloud is not optimized from the traffic forwarding's perspective. For the control plane The MME and PGW-F are implemented by NFV. For the dataplane the PGW-F/SGW-F can weither be implemented by NFV or lagacy devices. The second deployment scenario is the SIPTO/LIPA scenario which is discussed in 3GPP. In this scenario, DMM can provide optimized traffic offloading solution. The Third deploy scenario is the WLAN scenario. In this scenario, the AC is implemented in the cloud and the authentication status can maintained as the terminal move from one AP to another.

#### 4. Network Function Virtualization Scenario

This section discusses network function virtualization scenario, the associated control - data plane separation and the possible mobility management functions to support this scenario.

##### 4.1. Network function virtualization deployment architecture

The network function virtualization scenario is shown in Figure 1.

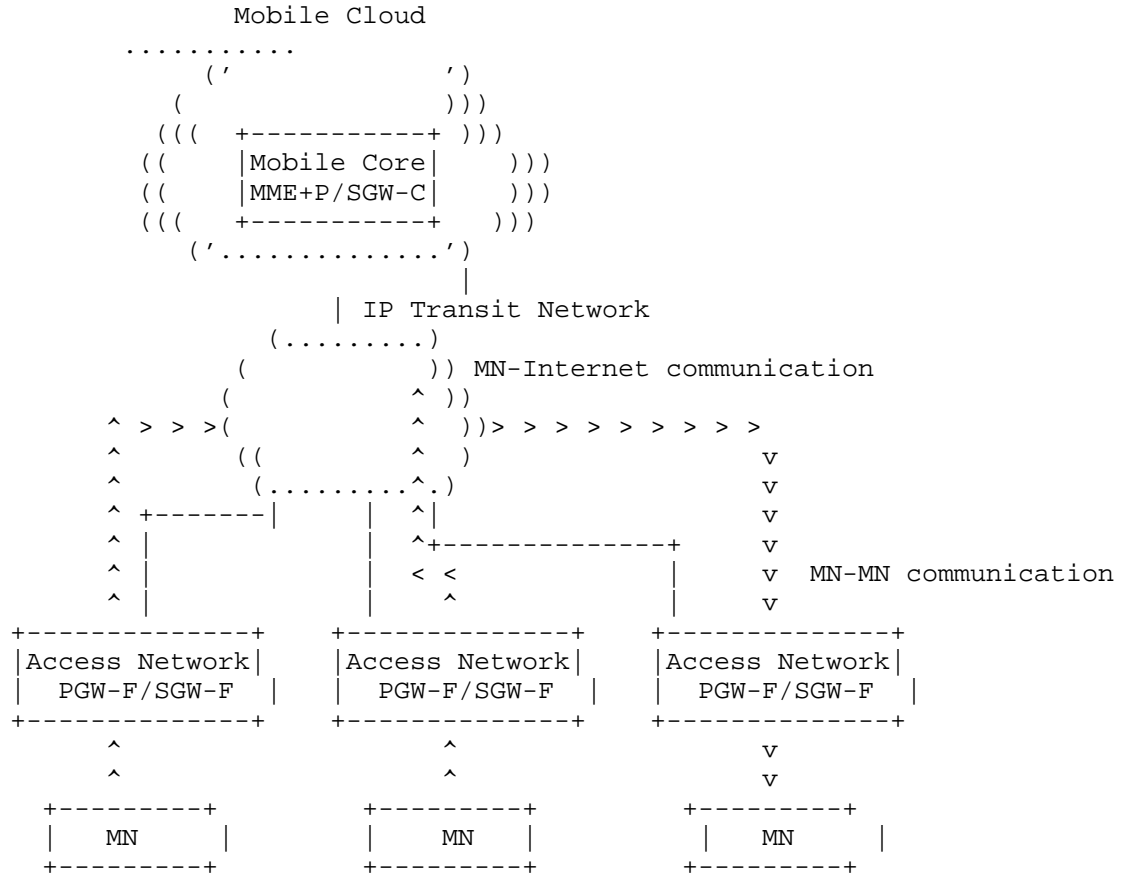


Figure 1: Network function virtualization deployment architecture

In this architecture, the mobile core include MME and PGW-F is located in the cloud data center, which can be the operator's private cloud using NFV. The access network contains PGW-F/SGW-F is connected through an IP transit network. The PGW-F/SGW-F may also implement by NFV of small data center in convergence layer. The architecture of NFV based Mobile Core is shown in Figure 2.

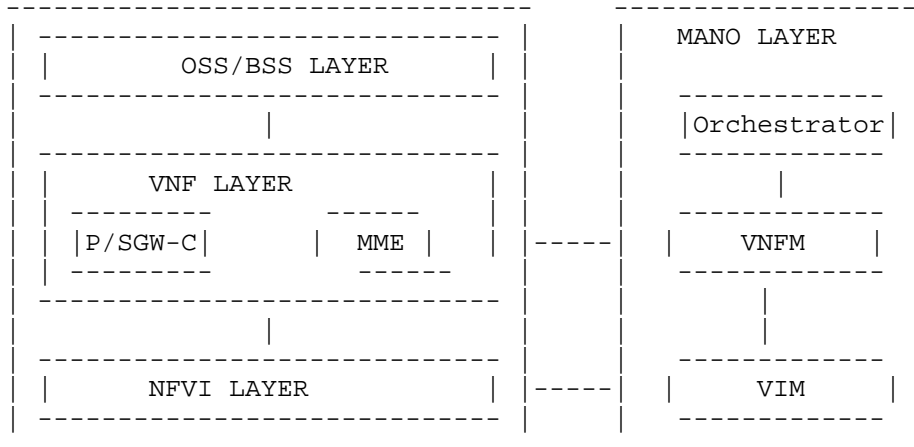


Figure 2: NFV based Mobile Core Architecture

In Figure 2, the MANO layer contains Orchestrator, VNFM and VIM. The Orchestrator is in charge of top-down service and source monitor and fulfillment. VNFM is in charge of manage the VNFs. And VIM normally is the Openstack which provide management of the whole virtualization layer.

#### 4.2. Control and data plane separation

The cloud based mobile core network architecture implies separation of the control and data planes. The control plane is located in the cloud and the data plane should be distributed. Otherwise, all the data traffic will go through the cloud which is obviously not optimized for the mobile node to mobile node communication. For the mobile node to Internet communication, the Internet access point is normally located in the metro IP transit network. In this case, the mobile node to Internet traffic should also go through the Internet access point instead of the mobile core in the cloud.

However, in some deployment scenario, the operator may choose to put the mobile core cloud in the convergence layer of IP metro network. In this case, the Internet access point may co-located with the mobile core cloud. In this case, the mobile node to Internet traffic may go through the mobile core cloud.

#### 4.3. Mobility management architecture

Since the control plane and data plane are separated and the data plane is distributed, traditional mobility management cannot meet

this requirement. Distributed mobility management or SDN based mobility management may be used in this architecture to meet the traffic forwarding requirement (e.g. MN to MN and MN to Internet traffic should not go through from the mobile core cloud.). The traditional mobility management functions is not separating the data plane from the control plane. Basic mobility management functions include location information (LI) function and Forwarding management (FM). The former is a control plane function. The latter can be separated into data plane forwarding management (FM-DP) and control plane forwarding management (FM-CP).

The data plane function is FM-DP, while the control plane functions include FM-CP and LI. Then the control plane functions in the cloud-based mobile core includes LI and FM-CP. They are of cause other functions in the control plane such as policy function. The

distributed data plane may have multiple instances of FM-DP in the network.

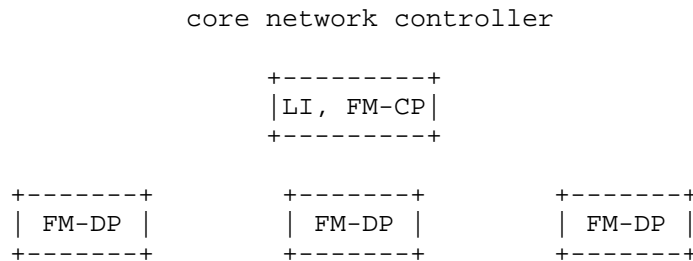


Figure 2: Mobility management functions with data plane - control plane separation under one controller When the control of the access network is separate from that of the core, there will be separate controllers as shown in Figure 3.

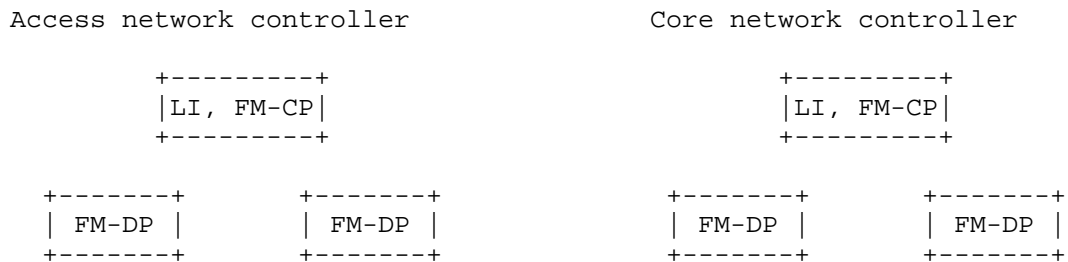




Figure 2: Mobility management functions with data plane - control plane separation with separate control in core and in access networks.

#### 4.4. NFV based deployment architecture

Here is the deployment architecture in NFV.

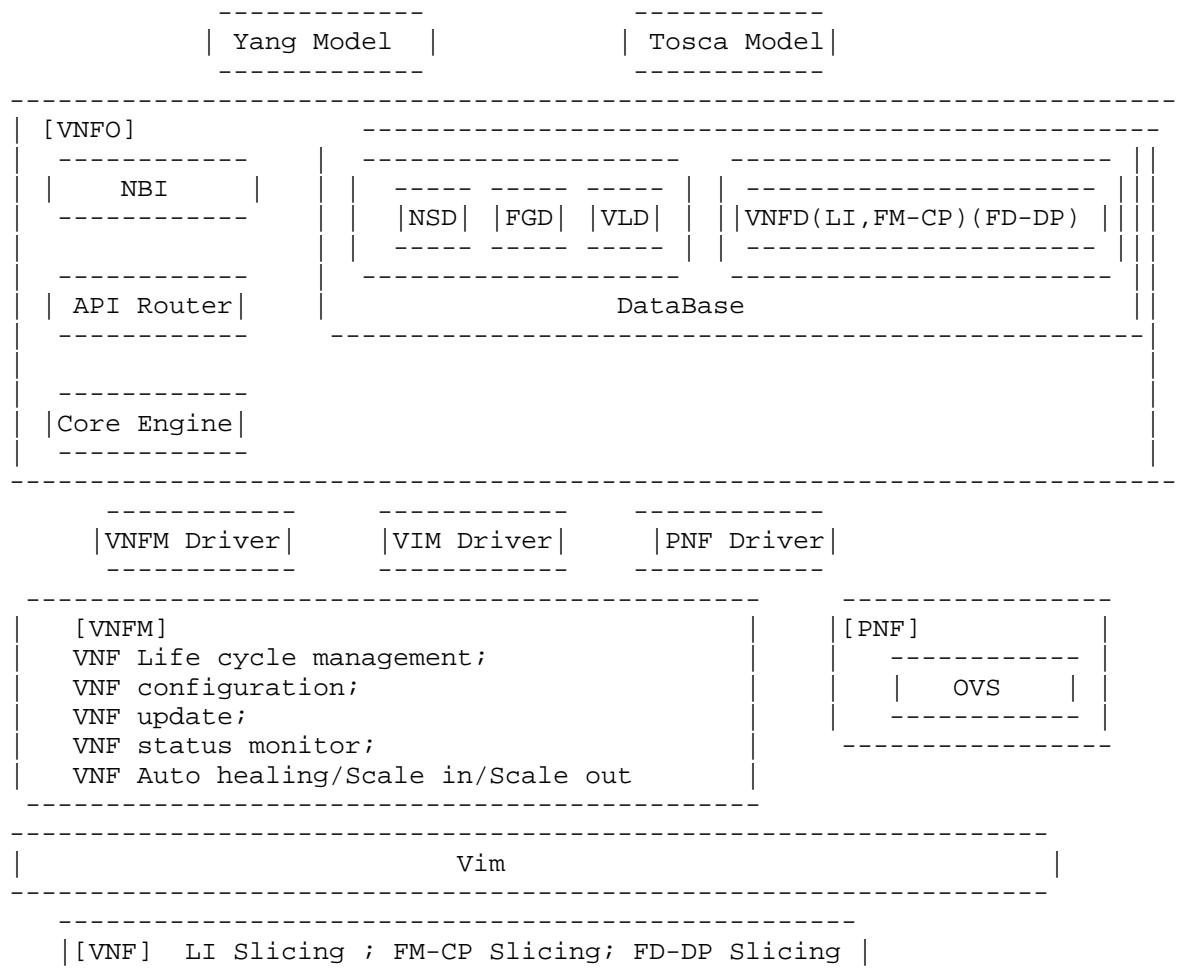


Figure 3 Deployment architecture

## 5. SIPTO deployment scenario

The Second deployment scenario is the SIPTO scenario which is discussed in 3GPP. DMM is believed to be able to provide dynamic anchoring. It allows the mobile node to have several anchoring points and to change the anchoring point according to the application requirement. In SIPTO scenario, the gateway function is located very near to the access network and to the user. If using current centralized mobility management, the traffic will need to tunnel back to the previous anchor point even when the mobile node has changed the point of attachment to a new one. Figure 3 shows the architecture of SIPTO.

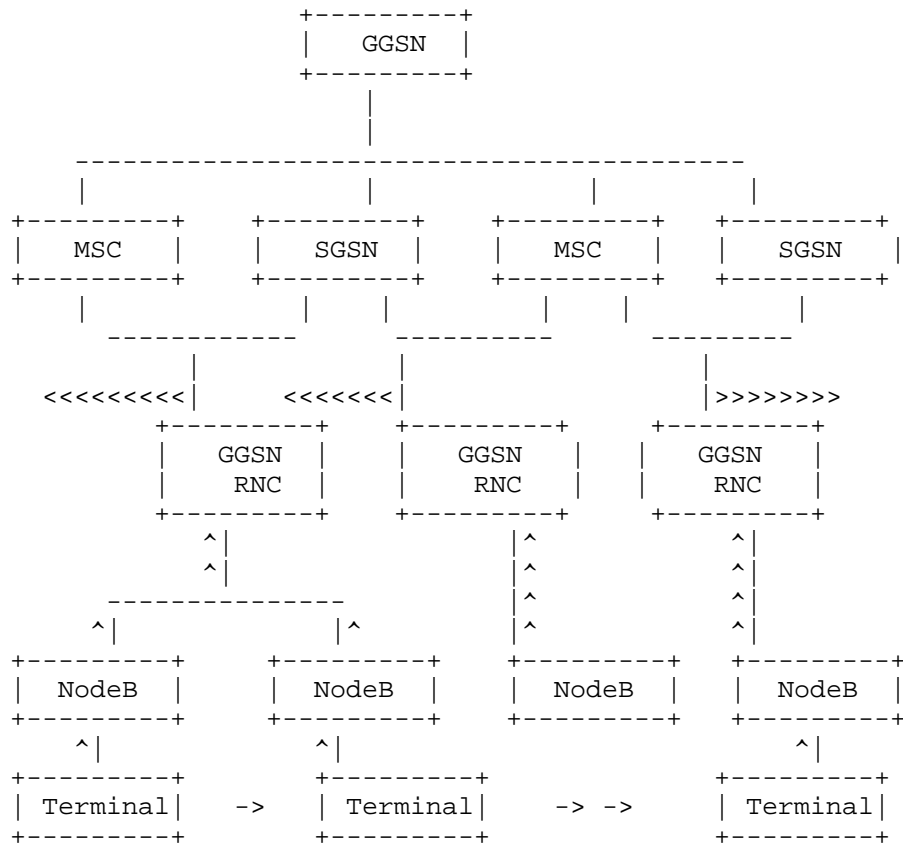
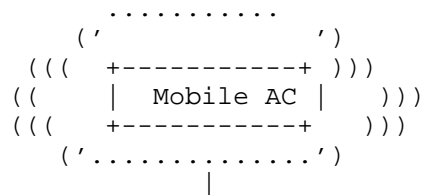


Figure 4 SIPTO Scenario

## 6. WLAN deployment scenario

The Third deployment scenario is the WLAN scenario. DMM can enable the AC in the cloud. The cloud AC and maintain the authentication and connection status. As the terminal move from one AP to another, it still can have the connection.



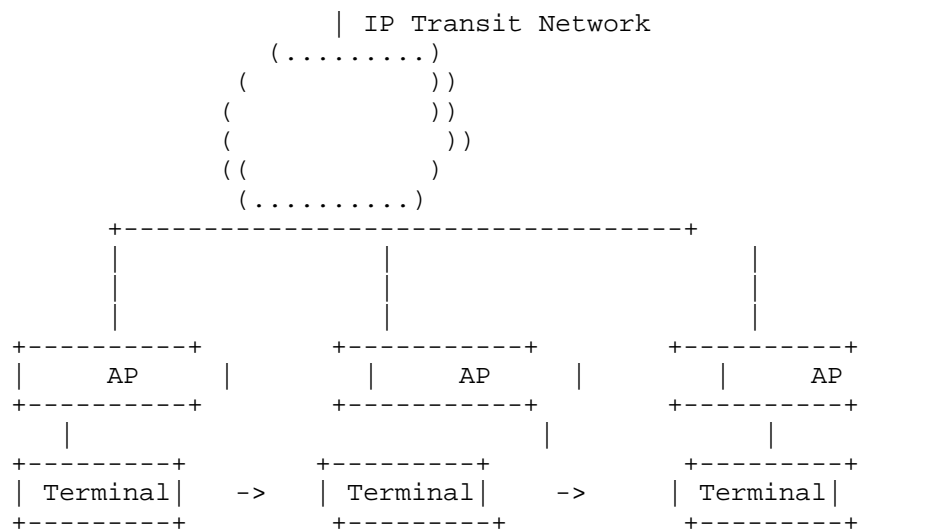


Figure 5 WLAN deployment scenario

## 7. Conclusion

This document discusses the deployment scenario of DMM. Three types of deployment scenario is discussed in this document. Further types of deployment scenario can be added to this document according to the progress of the group's discussion.

## 8. Security Considerations

N/A

## 9. IANA Considerations

N/A

## 10. Normative References

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