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H. Chan, Ed.
X. Wei
Huawei Technologies
J. Lee
Sangmyung University
S. Jeon
Sungkyunkwan University
CJ. Bernardos, Ed.
UC3M

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Distributed Mobility Anchoring
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Abstract

This document defines distributed mobility anchoring in terms of the different configurations and functions to provide IP mobility support. A network may be configured with distributed mobility anchoring functions for both network-based or host-based mobility support according to the needs of mobility support. In the distributed mobility anchoring environment, multiple anchors are available for mid-session switching of an IP prefix anchor. To start a new flow or to handle a flow not requiring IP session continuity as a mobile node moves to a new network, the flow can be started or re-started using a new IP address configured from the new IP prefix which is anchored to the new network. The mobility functions and their operations and parameters are general for different configurations.

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1. Introduction

A key requirement in distributed mobility management [RFC7333] is to enable traffic to avoid traversing a single mobility anchor far from an optimal route. This document defines different configurations, functional operations and parameters for distributed mobility anchoring and explains how to use them to make the route changes to avoid unnecessarily long routes.

Companion distributed mobility management documents are already addressing the architecture and deployment [I-D.ietf-dmm-deployment-models], source address selection [I-D.ietf-dmm-ondemand-mobility], and control-plane data-plane signaling [I-D.ietf-dmm-fpc-cpdp]. A number of distributed mobility solutions have also been proposed, for example, in [I-D.seite-dmm-dma], [I-D.bernardos-dmm-pmipv6-dlif], [I-D.sarikaya-dmm-for-wifi], [I-D.yhkim-dmm-enhanced-anchoring], and [I-D.matsushima-stateless-uplane-vepc].

Distributed mobility anchoring employs multiple anchors in the data plane. In general, control plane functions may be separated from data plane functions and be centralized but may also be co-located with the data plane functions at the distributed anchors. Different configurations of distributed mobility anchoring are described in Section 3.1.

As an MN attaches to an access router and establishes a link between them, a /64 IPv6 prefix anchored to the router may be assigned to the link for exclusive use by the MN [RFC6459]. The MN may then configure a global IPv6 address from this prefix and use it as the source IP address in a flow to communicate with its correspondent node (CN). When there are multiple mobility anchors, an address selection for a given flow is first required before the flow is initiated. Using an anchor in an MN's network of attachment has the advantage that the packets can simply be forwarded according to the forwarding table. However, after the flow has been initiated, the MN may later move to another network, so that the IP address no longer belongs to the current network of attachment of the MN.

The IP session continuity needs of a flow (application) determines the how the IP address used by the traffic of this flow has to be anchored. If the ongoing IP flow can cope with an IP prefix/address change, the flow can be reinitiated with a new IP address anchored in the new network. On the other hand, if the ongoing IP flow cannot cope with such change, mobility support is needed. A network supporting a mix of flows both requiring and not requiring IP mobility support will need to distinguish these flows.

2. Conventions and Terminology

All general mobility-related terms and their acronyms used in this document are to be interpreted as defined in the Mobile IPv6 (MIPv6) base specification [RFC6275], the Proxy Mobile IPv6 (PMIPv6) specification [RFC5213], the "Mobility Related Terminologies" [RFC3753], and the DMM current practices and gap analysis [RFC7429]. These include terms such as mobile node (MN), correspondent node

(CN), home agent (HA), home address (HoA), care-of-address (CoA), local mobility anchor (LMA), and mobile access gateway (MAG).

In addition, this document uses the following terms:

Home network of an application session or a home address: the network that has assigned the HoA used as the session identifier by the application running in an MN. The MN may be running multiple application sessions, and each of these sessions can have a different home network.

Anchoring (an IP prefix/address): An IP prefix, i.e., Home Network Prefix (HNP), or address, i.e., HoA, assigned for use by an MN is topologically anchored to an anchor node when the anchor node is able to advertise a connected route into the routing infrastructure for the assigned IP prefix.

Location Management (LM) function: that keeps and manages the network location information of an MN. The location information may be a binding of the advertised IP 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.

When the MN is a mobile router (MR) carrying a mobile network of mobile network nodes (MNN), the location information will also include the mobile network prefix (MNP), which is the aggregate IP prefix delegated to the MR to assign IP prefixes for use by the MNNs in the mobile network.

In a client-server protocol model, location query and update messages may be exchanged between a Location Management client (LMc) and a Location Management server (LMs), where the location information can be updated to or queried from the LMs. Optionally, there may be a Location Management proxy (LMp) between LMc and LMs.

With separation of control plane and data plane, the LM function is in the control plane. It may be a logical function at the control plane node, control plane anchor, or mobility controller.

It may be distributed or centralized.

Forwarding Management (FM) function: packet interception and forwarding to/from the IP address/prefix assigned for use by 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.

This function may be used to achieve traffic indirection. With separation of control plane and data plane, the FM function may split into a FM function in the data plane (FM-DP) and a FM function in the control plane (FM-CP).

FM-DP may be distributed with distributed mobility management. It may be a function in a data plane anchor or data plane node.

FM-CP may be distributed or centralized. It may be a function in a control plane node, control plane anchor or mobility controller.

3. Distributed Mobility Anchoring

3.1. Configurations for Different Networks

We next describe some configurations with multiple distributed anchors. To cover the widest possible spectrum of scenarios, we consider architectures in which the control and data planes are separated, as described in [I-D.ietf-dmm-deployment-models].

3.1.1. Network-based DMM

Figure 1 shows a general scenario for network-based distributed mobility management.

The main characteristics of a network-based DMM solution are:

There are multiple data plane anchors (i.e., DPA instances), each with an FM-DP function.

The control plane may either be distributed (not shown in the figure) or centralized (as shown in the figure).

The control plane and the data plane (Control Plane Anchor -- CPA -- and Data Plane Anchor -- DPA) may be co-located or not. If the CPA is co-located with the distributed DPAs, then there are multiple co-located CPA-DPA instances (not shown in the figure).

An IP prefix/address IP1 (anchored to the DPA with IP address IPa1) is assigned for use by an MN. The MN uses this IP1 address to communicate with CNs (not shown in the figure).

The location management (LM) function may be co-located or split (as shown in the figure) into a separate server (LMs) and a client (LMc). In this case, the LMs may be centralized whereas the LMc may be distributed or centralized, according to whether the CPA is distributed or centralized.

```
              ____________  Network
          ___/            \____________
         /      +-----+                \___
        (       |LMs  |    Control         \
       /        +-.---+    plane            \
      /  +--------.---+    functions         \
     (   |CPA:    .   |    in the             )
     (   |FM-CP, LMc  |    network            )
     (   +------------+                        \
    /          . .                              \
   (           .     .                           )
   (           .         .                       )
   (           .             .                   \
    \    +------------+ +------------+Distributed )
     (   |DPA(IPa1):  | |DPA(IPa2):  |DPAs        )
     (   |anchors IP1 | |anchors IP2 |          _/
      \  |FM-DP       | |FM-DP       | etc.    /
       \ +------------+ +------------+        /
        \___               Data plane  _____/
            \______        functions  /
                   \__________________/

         +------------+
         |MN(IP1)     | Mobile node attached
         |flow(IP1,..)| to the network
         +------------+
```

Figure 1: Network-based DMM configuration

3.1.2. Client-based DMM

Figure 2 shows a general scenario for client-based distributed mobility management. In this configuration, the mobile node performs Control Plane Node (CPN) and Data Plane Node (DPN) mobility functions, namely the forwarding management and location management (client role) ones.

```
          +-----+
          |LMs  |
          +-.---+
   +--------.---+
   |CPA:    .   |
   |FM-CP, LMp  |
   +------------+
         . .
         .     .
         .         .
         .             .
   +------------+ +------------+ Distributed
   |DPA(IPa1):  | |DPA(IPa2):  | DPAs
   |anchors IP1 | |anchors IP2 |
   |FM-DP       | |FM-DP       |  etc.
   +------------+ +------------+

   +------------+
   |MN(IP1)     |Mobile node
   |flow(IP1,..)|using IP1
   |FM,    LMc  |anchored to
   +------------+DPA(IPa1)
```

Figure 2: Client-based DMM configuration

4. IP Mobility Handling in Distributed Anchoring Environments - Mobility Support Only When Needed

IP mobility support may be provided only when needed instead of being provided by default.

A straightforward choice of mobility anchoring is for a flow to use the IP prefix of the network to which the MN is attached when the flow is initiated [I-D.seite-dmm-dma] [I-D.bernardos-dmm-pmipv6-dlif].

The IP prefix/address at the MN's side of a flow may be anchored at the access router to which the MN is attached. For example, when an MN attaches to a network (Net1) or moves to a new network (Net2), an IP prefix from the attached network is assigned to the MN's interface. In addition to configuring new link-local addresses, the MN configures from this prefix an IP address which is typically a dynamic IP address. It then uses this IP address when a flow is initiated. Packets to the MN in this flow are simply forwarded according to the forwarding table.

There may be multiple IP prefixes/addresses that an MN can select when initiating a flow. They may be from the same access network or

different access networks. The network may advertise these prefixes with cost options [I-D.mccann-dmm-prefixcost] so that the mobile node may choose the one with the least cost. In addition, these IP prefixes/addresses may be of different types regarding whether mobility support is needed [I-D.ietf-dmm-ondemand-mobility]. A flow will need to choose the appropriate one according to whether it needs IP mobility support.

4.1. No Need of IP Mobility: Changing to New IP Prefix/Address

When IP mobility support is not needed for a flow, the LM and FM functions are not utilized so that the configurations in Section 3.1 are simplified as shown in Figure 3.

```
Net1                                                    Net2

+---------------+                                       +---------------+
|AR1            |            AR is changed              |AR2            |
+---------------+              ------->                 +---------------+
|CPA:           |                                       |CPA:           |
|---------------|                                       |---------------|
|DPA(IPa1):     |                                       |DPA(IPa2):     |
|anchors IP1    |                                       |anchors IP2    |
+---------------+                                       +---------------+

+...............+                                       +---------------+
.MN(IP1)        .              MN moves                 |MN(IP2)        |
.flow(IP1,...)  .              =======>                 |flow(IP2,...)  |
+...............+                                       +---------------+
```

Figure 3: Changing to a new IP address/prefix

When there is no need to provide IP mobility to a flow, the flow may use a new IP address acquired from a new network as the MN moves to the new network.

Regardless of whether IP mobility is needed, if the flow has terminated before the MN moves to a new network, the flow may subsequently restart using the new IP address assigned from the new network.

When IP session continuity is needed, even if a flow is ongoing as the MN moves, it may still be desirable for the flow to change to using the new IP prefix configured in the new network. The flow may then close and then restart using a new IP address configured in the new network. Such a change in the IP address of the flow may be enabled using a higher layer mobility support which is not in the scope of this document.

In Figure 3, a flow initiated while the MN was using the IP prefix IP1 anchored to a previous access router AR1 in network Net1 has terminated before the MN moves to a new network Net2. After moving to Net2, the MN uses the new IP prefix IP2 anchored to a new access router AR2 in network Net2 to start a new flow. The packets may then be forwarded without requiring IP layer mobility support.

An example call flow is outlined in Figure 4

```
    MN                    AR1           AR2                            CN
     |MN attaches to AR1:  |             |                              |
     |acquire MN-ID and profile          |                              |
     |--RS---------------->|             |                              |
     |                     |             |                              |
     |<----------RA(IP1)---|             |                              |
     |                     |             |                              |
   Assigned prefix IP1     |             |                              |
   IP1 address configuration             |                              |
     |                     |             |                              |
     |<-Flow(IP1,IPcn,...)-+------------------------------------------->|
     |                     |             |                              |
     |MN detaches from AR1 |             |                              |
     |MN attaches to AR2   |             |                              |
     |                     |             |                              |
     |--RS------------------------------>|                              |
     |                     |             |                              |
     |<--------------RA(IP2)-------------|                              |
     |                     |             |                              |
   Assigned prefix IP2     |             |                              |
   IP2 address configuration             |                              |
     |                     |             |                              |
     |<-new Flow(IP2,IPcn,...)-----------+----------------------------->|
     |                     |             |                              |
```

Figure 4: Re-starting a flow with new IP prefix/address

4.2. Need of IP Mobility

When IP mobility is needed for a flow, the LM and FM functions in Section 3.1 are utilized. The mobility support may be provided by IP prefix anchor switching to the new network to be described in Section 5 or by using other mobility management methods ([Paper-Distributed.Mobility], [Paper-Distributed.Mobility.PMIP] and [Paper-Distributed.Mobility.Review]). Then the flow may continue to use the IP prefix from the prior network of attachment. Yet some time later, the user application for the flow may be closed. If the application is started again, the new flow may not need to use the prior network's IP address to avoid having to invoke IP mobility

support. This may be the case where a dynamic IP prefix/address rather than a permanent one is used. The flow may then use the new IP prefix in the network where the flow is being initiated. Routing is again kept simpler without employing IP mobility and will remain so as long as the MN which is now in the new network has not moved again and left to another new network.

An example call flow in this case is outlined in Figure 5.

```
 MN                     AR1           AR2                           CN
  |MN attaches to AR1:  |             |                             |
  |acquire MN-ID and profile          |                             |
  |--RS---------------->|             |                             |
  |                     |             |                             |
  |<----------RA(IP1)---|             |                             |
  |                     |             |                             |
Assigned prefix IP1     |             |                             |
IP1 address configuration             |                             |
  |                     |             |                             |
  |<-Flow(IP1,IPcn,...)-+------------------------------------------>|
  |                     |             |                             |
  |MN detach from AR1   |             |                             |
  |MN attach to AR2     |             |                             |
  |                     |             |                             |
  |--RS------------------------------>|                             |
IP mobility support such as that described in next sub-section
  |<--------------RA(IP2,IP1)---------|                             |
  |                     |             |                             |
  |<-Flow(IP1,IPcn,...)---------------+---------------------------->|
  |                     |             |                             |
Assigned prefix IP2     |             |                             |
IP2 address configuration             |                             |
  |                     |             |                             |
Flow(IP1,IPcn) terminates             |                             |
  |                     |             |                             |
  |<-new Flow(IP2,IPcn,...)-----------+---------------------------->|
  |                     |             |                             |
```

Figure 5: A flow continues to use the IP prefix from its home network after MN has moved to a new network

Multiple instances of DPAs (at access routers), which are providing IP prefix to the MNs, are needed to provide distributed mobility anchoring in an appropriate configuration such as those described in Figure 1 (Section 3.1.1) for network-based distributed mobility or in Figure 2 (Section 3.1.2) for client-based distributed mobility.

5. IP Mobility Handling in Distributed Mobility Anchoring Environments - Anchor Switching to the New Network

IP mobility is invoked to enable IP session continuity for an ongoing flow as the MN moves to a new network. Here the anchoring of the IP address of the flow is in the home network of the flow, which is not in the current network of attachment. A centralized mobility management mechanism may employ indirection from the anchor in the home network to the current network of attachment. Yet it may be difficult to avoid unnecessarily long route when the route between the MN and the CN via the anchor in the home network is significantly longer than the direct route between them. An alternative is to switch the IP prefix/address anchoring to the new network.

5.1. IP Prefix/Address Anchor Switching for Flat Network

The IP prefix/address anchoring may move without changing the IP prefix/address of the flow. Here the LM and FM functions in Figure 1 in Section 3.1 are implemented as shown in Figure 6.

```
Net1                                                  Net2

+---------------+                                     +---------------+
|AR1            |                                     |AR2            |
+---------------+                                     +---------------+
|CPA:           |                                     |CPA:           |
|LM:IP1 at IPa1 |                                     |LM:IP1 at IPa2 |
|   changes to  |                                     |               |
|   IP1 at IPa2 |                                     |               |
|---------------|                                     |---------------|
|DPA(IPa1):     | IP1 anchoring is effectively moved|DPA(IPa2):     |
|anchored IP1   |             =======>                |anchors IP2,IP1|
+---------------+                                     +---------------+

+...............+                                     +---------------+
.MN(IP1)        .             MN moves                |MN(IP2,IP1)    |
.flow(IP1,...)  .             =======>                |flow(IP1,...)  |
+...............+                                     +---------------+
```

Figure 6: Anchor mobility

As an MN with an ongoing session moves to a new network, the flow may preserve IP session continuity by moving the anchoring of the original IP prefix/address of the flow to the new network.

One way to accomplish such move is to use a centralized routing protocol, but note that this solution presents some scalability

concerns and its applicability is typically limited to small networks.

6. Security Considerations

Security protocols and mechanisms are employed to secure the network and to make continuous security improvements, and a DMM solution is required to support them [RFC7333].

In a DMM deployment [I-D.ietf-dmm-deployment-models] various attacks such as impersonation, denial of service, man-in-the-middle attacks need to be prevented.

7. IANA Considerations

This document presents no IANA considerations.

8. Contributors

Alexandre Petrescu and Fred L. Templin had contributed to earlier versions of this document regarding distributed anchoring for hierarchical network and for network mobility, although these extensions were removed to keep the document within reasonable length.

This document has benefited from other work on mobility support in SDN network, on providing mobility support only when needed, and on mobility support in enterprise network. These works have been referenced. While some of these authors have taken the work to jointly write this document, others have contributed at least indirectly by writing these drafts. The latter include Philippe Bertin, Dapeng Liu, Satoru Matushima, Pierrick Seite, Jouni Korhonen, and Sri Gundavelli.

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Authors' Addresses

H. Anthony Chan (editor)
Huawei Technologies
5340 Legacy Dr. Building 3
Plano, TX 75024
USA

Email: h.a.chan@ieee.org

Xinpeng Wei
Huawei Technologies
Xin-Xi Rd. No. 3, Haidian District
Beijing, 100095
P. R. China

Email: weixinpeng@huawei.com

Jong-Hyouk Lee
Sangmyung University
31, Sangmyeongdae-gil, Dongnam-gu
Cheonan 31066
Republic of Korea

Email: jonghyouk@smu.ac.kr

Seil Jeon
Sungkyunkwan University
2066 Seobu-ro, Jangan-gu
Suwon, Gyeonggi-do
Republic of Korea

Email: seiljeon@skku.edu

Carlos J. Bernardos (editor)
Universidad Carlos III de Madrid
Av. Universidad, 30
Leganes, Madrid 28911
Spain

Phone: +34 91624 6236
Email: cjbc@it.uc3m.es
URI: http://www.it.uc3m.es/cjbc/