DMM Deployment Models and Architectural Considerations
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Abstract

   This document identifies the deployment models for Distributed
   Mobility Management architecture.

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1. Overview

   One of the key aspects of the Distributed Mobility Management (DMM)
   architecture is the separation of control plane (CP) and data plane
   (DP) functions of a network element. While data plane elements
   continue to reside on customized networking hardware, the control
   plane resides as a software element in the cloud. This is usually
   referred to as CP-DP separation and is the basis for the IETF's DMM
   Architecture. This approach of centralized control plane and
   distributed data plane allows elastic scaling of control plane and
   efficient use of common data plane that is agnostic to access
   architectures.

   This document identifies the functions in the DMM architecture and
   the supported deployment models.

2. Conventions and Terminology

2.1. Conventions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
"SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this
document are to be interpreted as described in RFC 2119 [RFC2119].

2.2. Terminology

All the mobility related terms are to interpreted as defined in
[RFC6275], [RFC5213], [RFC5844], [RFC7333], [RFC7665], [RFC7429],
[RFC8300] and [I-D.ietf-dmm-fpc-cpdp]. Additionally, this document
uses the following terms:

Home Control-Plane Anchor (Home-CPA or H-CPA)

   The Home-CPA function hosts the mobile node (MN)'s mobility
   session. There can be more than one mobility session for a mobile
   node and those sessions may be anchored on the same or different
   Home-CPA's. The home-CPA will interface with the home-DPA for
   managing the forwarding state.

Home Data Plane Anchor (Home-DPA or H-DPA)

   The Home-DPA is the topological anchor for the MN's IP address/
   prefix(es). The Home-DPA is chosen by the Home-CPA on a session-
   basis. The Home-DPA is in the forwarding path for all the mobile
   node's IP traffic.

Access Control Plane Node (Access-CPN or A-CPN)

   The Access-CPN is responsible for interfacing with the mobile
   node's Home-CPA and with the Access-DPN. The Access-CPN has a
   protocol interface to the Home-CPA.

Access Data Plane Node (Access-DPN or A-DPN)

   The Access-DPN function is hosted on the first-hop router where
   the mobile node is attached. This function is not hosted on a
   layer-2 bridging device such as a eNode(B) or Access Point.

Routing Controller (RC)

   The Routing Controller is a centralized control entity, which is
   able to instruct the forwarding behavior for mobility management
   in Home-DPA and Access-DPN.

   Mobility Controller (MC)

      The Mobility Controller is a function entity, which is able to
      manage the orchestration of Home-CPA and Access-CPN functions.

3. DMM Architectural Overview

   Following are the key goals of the Distributed Mobility Management
   architecture.

   1. Separation of control and data Plane

   2. Aggregation of control plane for elastic scaling

   3. Distribution of the data plane for efficient network usage

   4. Elimination of mobility state from the data plane

   5. Dynamic selection of control and data plane nodes

   6. Enabling the mobile node with network properties

   7. Relocation of anchor functions for efficient network usage

3.1. DMM Service Primitives

   The functions in the DMM architecture support a set of service
   primitives. Each of these service primitives identifies a specific
   service capability with the exact service definition. The functions
   in the DMM architecture are required to support a specific set of
   service primitives that are mandatory for that service function. Not
   all service primitives are applicable to all DMM functions. The
   below table as shown in Fig. 1 identifies the service primitives that
   each of the DMM function SHOULD support. The marking "X" indicates
   the service primitive on that row needs to be supported by the
   identified DMM function on the corresponding column; for example, the
   IP address management MUST be supported by Home-CPA function. The
   NSH Classifier denotes the SFC entity that performs the
   classification of a service flow, defined in [RFC7665].

```
+=================+=======+=======+=======+=======+=======+=======+
|   Service       | H-CPA | H-DPA | A-CPN | A-DPN |  MC   |  RC   |
| Primitive       |       |       |       |       |       |       |
+=================+=======+=======+=======+=======+=======+=======+
| IP Management   |   X   |       |       |       |   X   |       |
+-----------------+-------+-------+-------+-------+-------+-------+
| IP Anchoring    |       |   X   |       |       |       |       |
+-----------------+-------+-------+-------+-------+-------+-------+
| MN Detection    |       |       |   X   |   X   |       |       |
+-----------------+-------+-------+-------+-------+-------+-------+
| Routing         |       |   X   |       |   X   |       |       |
+-----------------+-------+-------+-------+-------+-------+-------+
| Tunneling       |       |   X   |       |   X   |       |       |
+-----------------+-------+-------+-------+-------+-------+-------+
| QoS Enforcement |       |   X   |       |   X   |       |       |
+-----------------+-------+-------+-------+-------+-------+-------+
| FPC Client      |   X   |       |   X   |       |   X   |       |
+-----------------+-------+-------+-------+-------+-------+-------+
| FPC Agent       |       |   X   |       |   X   |       |   X   |
+-----------------+-------+-------+-------+-------+-------+-------+
| NSH Classifier  |       |   X   |       |   X   |       |       |
+-----------------+-------+-------+-------+-------+-------+-------+
```

Figure 1: Role or capability of DMM functions

3.2. DMM Functions and Interfaces

3.2.1. Home Control-Plane Anchor (Home-CPA):

The Home-CPA function hosts the mobile node's mobility session.
There can be more than one mobility session for a mobile node and
those sessions may be anchored on the same or different Home-CPA's.
The home-CPA will interface with the home-dpa for managing the
forwarding state.

There can be more than one Home-CPA serving the same mobile node at a
given point of time, each hosting a different control plane session.

The Home-CPA is responsible for life cycle management of the session,
interfacing with the policy infrastructure, policy control and
interfacing with the Home-DPA functions.

The Home-CPA function typically stays on the same node. In some
special use-cases (Ex: Geo-Redundancy), the session may be migrated
to a different node and with the new node assuming the Home-CPA role
for that session.

3.2.2. Home Data-Plane Anchor (Home-DPA):

The Home-DPA is the topological anchor for the mobile node's IP
address/prefix(es). The Home-DPA is chosen by the Home-CPA/MC on a
session-basis. The Home-DPA is in the forwarding path for all the
mobile node's IP traffic.

As the mobile node roams in the mobile network, the mobile node's
access-DPN may change, however, the Home-DPA does not change, unless
the session is migrated to a new node.

The Home-DPA interfaces with the Home-CPA/MC for all IP forwarding
and QoS rules enforcement.

The Home-DPA and the Access-DPN functions may be collocated on the
same node.

3.2.3. Access Control Plane Node (Access-CPN)

The Access-CPN is responsible for interfacing with the mobile node's
Home-CPA and with the Access-DPN. The Access-CPN has a protocol
interface to the Home-CPA.

The Access-CPN is responsible for the mobile node's Home-CPA
selection based on: Mobile Node's Attach Preferences, Access and
Subscription Policy, Topological Proximity and Other Considerations.

The Access-CPN function is responsible for MN's service
authorization. It will interface with the access network
authorization functions.

3.2.4. Access Data Plane Node (Access-DPN)

The Access-DPN function is hosted on the first-hop router where the
mobile node is attached. This function is not hosted on a layer-2
bridging device such as a eNode(B) or Access Point.

The Access-DPA will have a protocol interface to the Access-CPA.

The Access-DPN and the Home-DPA functions may be collocated on the
same node.

3.2.5. DMM Functions Mapping to Other Architectures

Following table identifies the potential mapping of DMM functions to
protocol functions in other system architectures.

```
+=======+=========+========+=========+=============+==========+=======+
| Func. |  PMIPv6 |  MIPv6 |  IPsec  |  3GPP-SAE   |   BBF    |  5GC  |
+=======+=========+========+=========+=============+==========+=======+
| H-CPA | LMA-CPA | HA-CPA | IKE-CPA | PGW-CPA/MME |  BNG-CPA |AMF/SMF|
+-------+---------+--------+---------+-------------+----------+-------+
| H-DPA | LMA-DPA | HA-DPA | IKE-DPA | PGW-DPA     |  BNG-DPA |  UPF  |
+-------+---------+--------+---------+-------------+----------+-------+
| A-CPN | MAG-CPN |   -    |    -    | SGW-CPN     |  RG-CPN  |  SMF  |
+-------+---------+--------+---------+-------------+----------+-------+
| A-DPN | MAG-DPN |   -    |    -    | SGW-DPN     |  RG-DPN  |  UPF  |
+-------+---------+--------+---------+-------------+----------+-------+
```

       Figure 2: Mapping of DMM functions in other system architectures

   Mapping from the DMM functions to network components in PMIPv6,
   MIPv6, IPsec, Broadband Forum (BBF) can be given straight-forward.
   In the 3GPP System Architecture Evolution (SAE), H-CPA functionality
   is charged by PGW-CPA and Mobility Management Entity (MME), as MME is
   the key control-plane node involving in such as location management,
   handoff management, selection of SGW/PGW as well as authorization of
   UEs. But PGW-CPA is in charge of tunnel control based on UE's
   subscription and policy between SGW and PGW. The rest of the 3GPP
   SAE network components are as given in Fig. 2.

   The 3GPP Release 15 introduces the Service-Based Architecture (SBA)
   for 5G networks. The 3GPP 5G architecture can be represented by
   reference point or service-based interfaces [3GPP.23.501]. Allowing
   the service-based interface provides greater flexibility for updates
   and extensions of the 5G control plane system by operator's need or
   request. The architecture introduces various kinds of network
   functions granularized in the CP/DP separation concept. In Fig. 2,
   Access and Mobility Management Function (AMF), Session Management
   Function (SMF), and User Plane Function (UPF) are picked up among all
   the network functions introduced in the 5G SBA for mapping to the DMM
   functions.

   AMF and SMF take major roles for mobility management in control
   plane. AMF manages access control and mobility and includes network
   slice selection functionality. SMF manages sessions based on UE's
   subscription and network policy and is in charge of IP address
   allocation management. UPF is the data plane node, which works for
   data packet handling based on forwarding policy regulated by control
   plane nodes such as AMF and SMF, etc.

4. Deployment Models

   This section identifies the key deployment models for the DMM
   architecture.

4.1. Model-1: Split Home Anchor Mode

   In this model, the control and the data plane functions of the home
   anchor are separated and deployed on different nodes. The control
   plane function of the Home anchor is handled by the Home-CPA and
   where as the data plane function is handled by the Home-DPA. In this
   model, the access node operates in the legacy mode with the
   integrated control and user plane functions.

   The FPC interface defined in [I-D.ietf-dmm-fpc-cpdp] allows the
   control plane functions to interact with the data plane for the
   subscriber's forwarding state management.

```
                        +============+
                        |   Policy   |
              . . . . . .|  Function  |. . . . . . .
              .          +============+          .
              .                                  .
              .                                  .
              .                                  .
         +============+       {PMIPv6/GTP}       +============+
         |            |- - - - - - - - - - - -|  Home-CPA  |
         |            |                        +============+
         |            |                              .
         |            |                              . FPC
         | Access Node|                              .
         |            |                              .
         | (CPN + DPN)|                              .
         |            |                        +============+
         |   Legacy   |. . . . . . . . . . . .|  Home-DPA  |
         +============+   UP {Tunnel/Route}     +============+
              .
               .
            +--+
            |MN|
            +--+
```
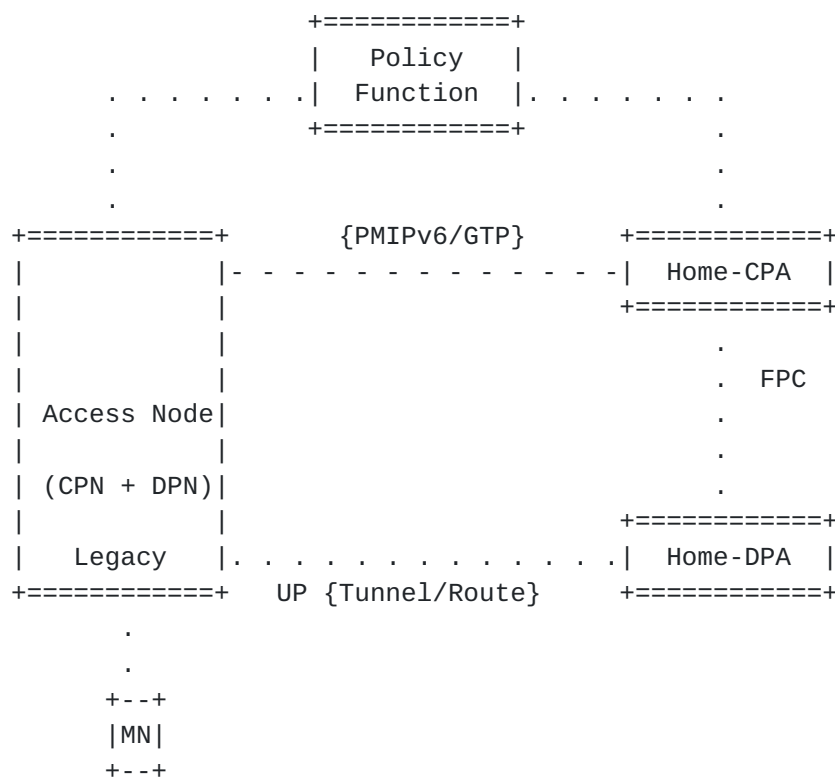
                    Figure 3: Split Home Anchor Mode

4.2. Model-2: Separated Control and User Plane Mode

   In this model, the control and the data plane functions on both the
   home anchor and the access node are seperated and deployed on
   different nodes. The control plane function of the Home anchor is
   handled by the Home-CPA whereas the data plane function is handled by
   the Home-DPA. The control plane function of the access node is
   handled by the Access-CPN and where as the data plane function is
   handled by the Access-DPN.

   The FPC interface defined in [I-D.ietf-dmm-fpc-cpdp] allows the
   control plane functions of the home and access nodes to interact with
   the respective data plane functions for the subscriber's forwarding
   state management.

```
                           +============+
                           |   Policy   |
                 . . . . . .|  Function  |. . . . . .
                 .          +============+          .
                 .                                  .
                 .                                  .
                 .                                  .
                 .                                  .
          +============+    {PMIPv6/GTP}       +============+
          | Access-CPN |- - - - - - - - - - - |  Home-CPA  |
          +============+                       +============+
                 .                                  .
                 .  FPC                             .  FPC
                 .                                  .
                 .                                  .
                 .                                  .
          +============+                       +============+
          | Access-DPN |. . . . . . . . . .    |  Home-DPA  |
          +============+   UP {Tunnel/Route}   +============+
                .
                .
              +--+
              |MN|
              +--+
```


                 Figure 4: Seperated Control and User Plane Mode

4.3. Model-3: Centralized Control Plane Mode

   In this model, the control-plane functions of the home and the access
   nodes are collapsed. This is a flat architecture with no signaling
   protocol between the access node and home anchors. The interface
   between the Home-CPA and the Access-DPN is internal to the system.

   The FPC interface defined in [I-D.ietf-dmm-fpc-cpdp] allows the
   mobility controller to interact with the respective data plane
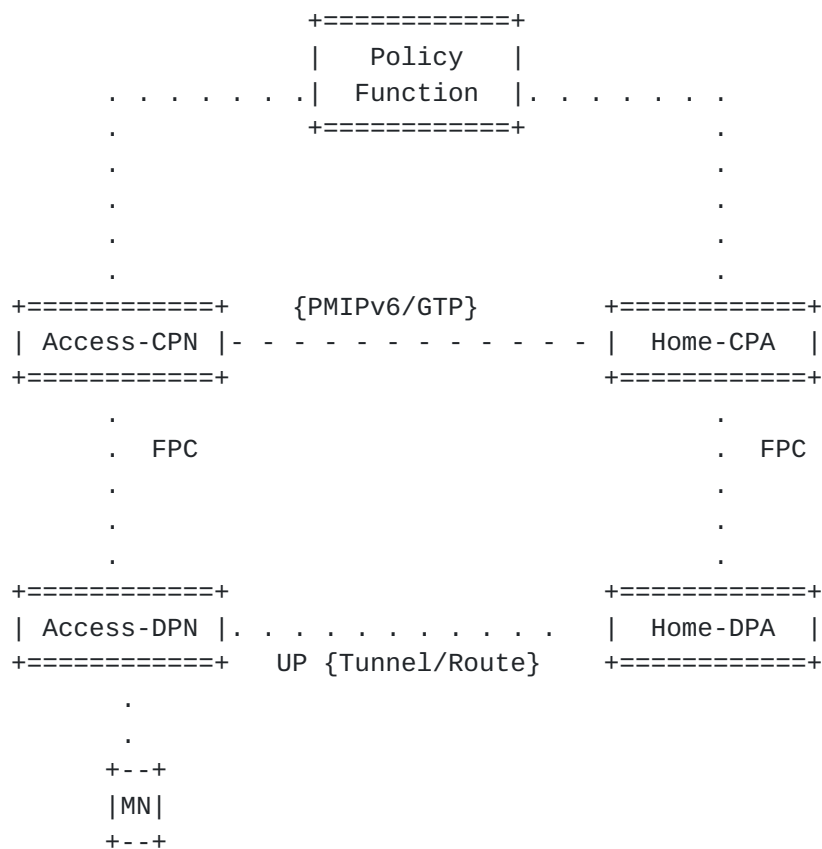   functions for the subscriber's forwarding state management.

```
             +======================+      +============+
             | Home-CPA + Access-CPN |      |   Policy   |
             |                      |-----| Function   |
             +======================+      +============+
                      .
                     .      .
                    .        .
               FPC .          .  FPC
                 .              .
                .                .
         +============+                    +============+
         | Access-DPN |. . . . .  . . .|   Home-DPA  |
         +============+ UP {Tunnel/Route}  +============+
              .
              .
           +--+
           |MN|
           +--+
```
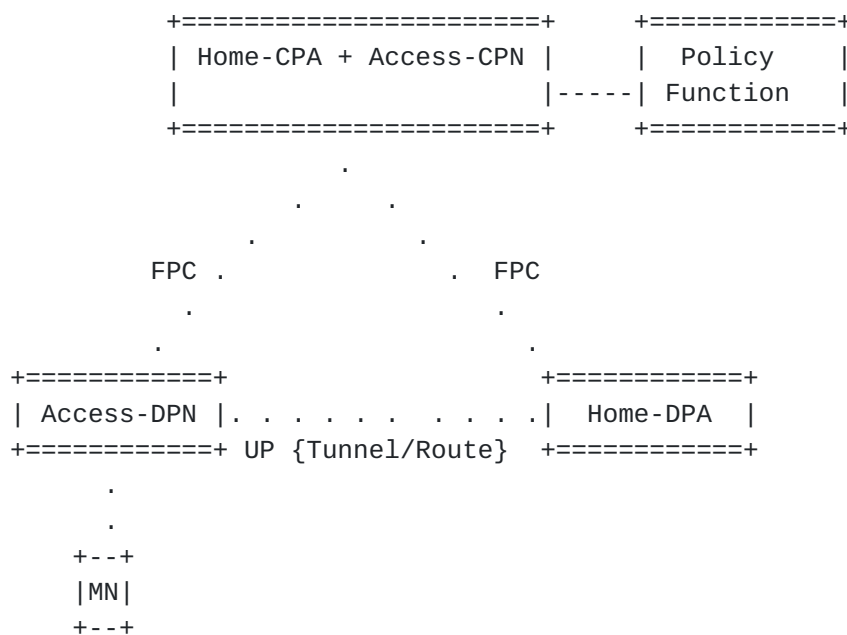
                 Figure 5: Centralized Control Plane Mode

4.4. Model-4: Data Plane Abstraction Mode

   In this model, the data plane network is completely abstracted from
   the control plane. There is a new network element, Routing
   Controller which abstracts the entire data plane network and offers
   data plane services to the control plane functions. The control
   plane functions, Home-CPA and the Access-CPN interface with the
   Routing Controller for the forwarding state management.

   The FPC interface defined in [I-D.ietf-dmm-fpc-cpdp] allows the Home-
   CPA and Access-CPN functions to interface with the Routing Controller
   for subscriber's forwarding state management.

```
                        +============+
                        |   Policy   |
            . . . . . . .|  Function  |. . . . . . .
            .           +============+           .
            .                                    .
            .                                    .
            .                                    .
            .                                    .
     +============+    {PMIPv6/GTP}        +============+
     | Access-CPN |- - - - - - - - - - - - |  Home-CPA  |
     +============+                        +============+
            .                                    .
            .                                    .
            .                                    .
            .              +============+        .
            . . . . . . | Routing     | . . . . . . .
                        | Controller |
                        +============+
                              .
                           .     .
                         .           .  BGP/Others
                       .                 .
                     .                     .
                   .                        .
     +============+                        +============+
     | Access-DPN |. . . . . .  . . . .|  Home-DPA  |
     +============+ UP {Tunnel/Route}   +============+
          .
          .
        +--+
        |MN|
        +--+
```
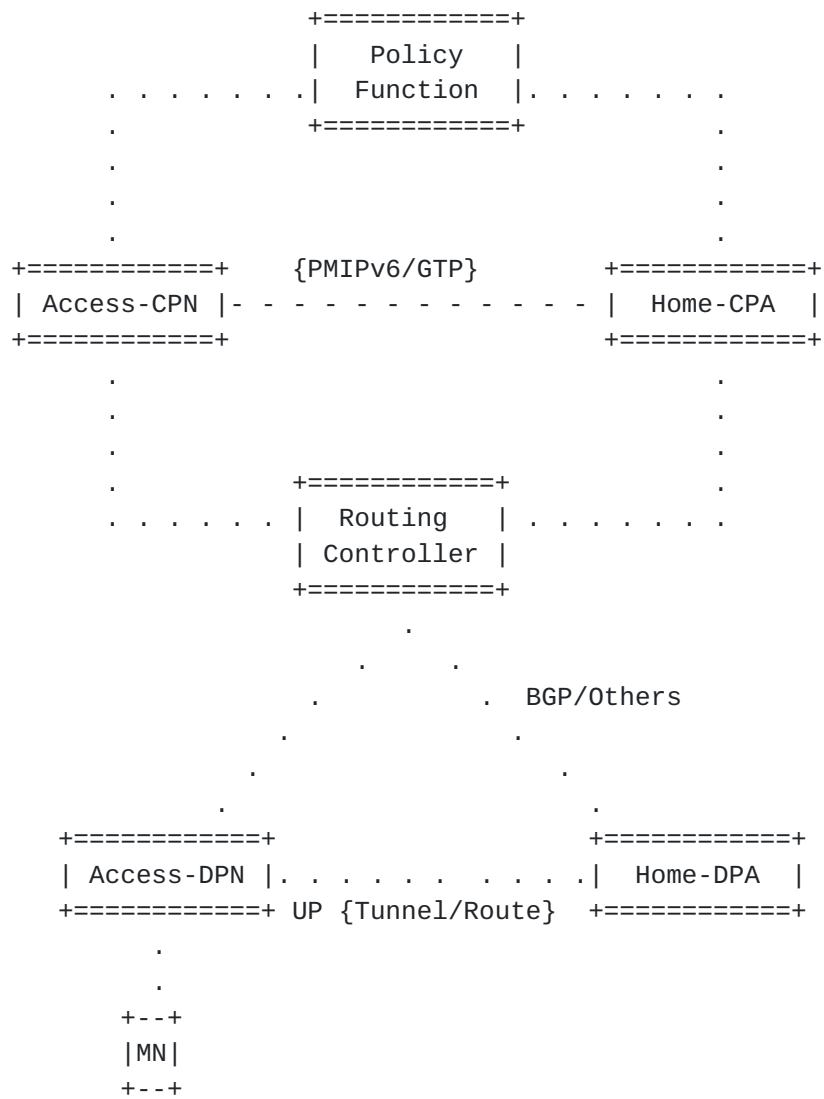
                 Figure 6: Data Plane Abstraction Mode

4.5. Model-5: On-Demand Control Plane Orchestration Mode

   In this model, there is a new function Mobility Controller which
   manages the orchestration of Access-CPN and Home-CPA functions. The
   Mobility Controller allocates the Home-CPA and Access-DPN

```
+ - - - - - - - - - - - - - - - - - - - - - - - - - - -+
|     +----------+     +----------+      +----------+    |
      |Access-CPN|     |Access-CPN|      |Access-CPN|
|     +----------+     +----------+      +----------+    |

|     +----------+     +----------+      +----------+    |
      | Home-CPA |     | Home-CPA |      | Home-CPA |
|     +----------+     +----------+      +----------+    |
+ - - - - - - - - - - - - - - - - - - - - - - - - - -+
             .                  .
             .                  .
             .                  .
             .            +============+      +============+
             .            |  Mobility  |      |   Policy   |
             .            | Controller |-----| Function    |
             .            +============+      +============+
             .
             .
             .
             .            +============+
       . . . . . .|   Routing   |
                          | Controller |
                          +============+
                                .
                                .
                                .
+ - - - - - - - - - - - - - - - - - - - - - - - - - - -+
|     +----------+     +----------+      +----------+    |
      |Access-DPN|     |Access-DPN|      |Access-DPN|
|     +----------+     +----------+      +----------+    |

|     +----------+     +----------+      +----------+    |
      | Home-DPA |     | Home-DPA |      | Home-DPA |
|     +----------+     +----------+      +----------+    |
+ - - - - - - - - - - - - - - - - - - - - - - - - - - -+
```

                  Figure 7: On-Demand CP Orchestration Mode

5. IANA Considerations

   This document does not require any IANA actions.

6. Security Considerations

The control-plane messages exchanged between a Home-CPA and the Home-DPA must be protected using end-to-end security associations with data-integrity and data-origination capabilities.

IPsec ESP in transport mode with mandatory integrity protection should be used for protecting the signaling messages. IKEv2 should be used to set up security associations between the Home-CPA and Home-DPA.

There are no additional security considerations other than what is presented in the document.

7. Work Team

This document reflects contributions from the following work team members:

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