              Separation of Control and User Plane for Proxy Mobile IPv6

Abstract

   This document specifies a method to split the control plane (CP) and
   user plane (UP) for a network infrastructure based on Proxy Mobile
   IPv6 (PMIPv6). Existing specifications allow a mobile access gateway
   (MAG) to separate its control and user plane using the Alternate
   Care-of Address mobility option for IPv6 or Alternate IPv4 Care-of
   Address option for IPv4. However, the current specification does not
   provide any mechanism allowing the local mobility anchor (LMA) to
   perform an analogous functional split. To remedy that shortcoming,
   this document specifies a mobility option enabling an LMA to provide
   an alternate LMA address to be used for the bidirectional user-plane
   traffic between the MAG and LMA. With this new option, an LMA will
   be able to use an IP address for its user plane that is different
   than the IP address used for the control plane.

Status of This Memo

   This is an Internet Standards Track document.

   This document is a product of the Internet Engineering Task Force
   (IETF). It represents the consensus of the IETF community. It has
   received public review and has been approved for publication by the
   Internet Engineering Steering Group (IESG). Further information on
   Internet Standards is available in Section 2 of RFC 5741.

   Information about the current status of this document, any errata,
   and how to provide feedback on it may be obtained at
   http://www.rfc-editor.org/info/rfc7389.

Copyright Notice

Table of Contents

1. Introduction

   A Proxy Mobile IPv6 (PMIPv6) infrastructure comprises two primary
   entities: LMA (local mobility anchor) and MAG (mobile access
   gateway). The interface between the MAG and LMA consists of the
   control plane and user plane. The control plane is responsible for
   signaling messages between the MAG and LMA, such as the Proxy Binding
   Update (PBU) and Proxy Binding Acknowledgement (PBA) messages to
   establish a mobility binding. In addition, the control-plane
   components in the MAG and LMA are also responsible for setting up and
   tearing down a bidirectional tunnel between the MAG and LMA. The
   user plane is used for carrying the mobile node's IP traffic between
   the MAG and the LMA over the bidirectional tunnel.

Widely deployed mobility management systems for wireless
communications require separation of IP transport for forwarding
user-plane and control-plane traffic. This separation offers more
flexible deployment options for LMA and MAG entities in Proxy Mobile
IPv6, as described in [MOBILE-SEPARATION]. To meet this requirement
would also require that the control-plane functions of the LMA be
addressable at a different IP address than the IP address assigned
for the user plane. However, PMIPv6 does not currently specify a
mechanism for allowing the LMA to separate the control plane from the
user plane. The LMA is currently required to associate the IP
address of the tunnel source with the target IP address for the
control messages received from the MAG.

The control-plane and user-plane components of a MAG or LMA are
typically co-located in the same physical entity. However, there are
situations where it is desirable to have the control and user plane
of a MAG or LMA in separate physical entities. For example, in a
WLAN (Wireless LAN) network, it may be desirable to have the control-
plane component of the MAG reside on the Access Controller (also
sometimes referred to as Wireless LAN Controller (WLC)) while the
user-plane component of the MAG resides on the WLAN Access Point.
This enables all the control-plane messages to the LMA to be
centralized while the user plane would be distributed across the
multiple Access Points. Similarly, there is a need for either the
control-plane or user-plane component of the LMA to be separated
according to different scaling requirements or, in other cases, the
need to centralize the control plane in one geographical location
while distributing the user-plane component across multiple
locations. For example, as illustrated in Figure 1, the LMA and MAG
could have one control session established for PMIPv6 control
signaling while maintaining separate connectivity via Generic Routing
Encapsulation (GRE) or IP-in-IP tunneling for forwarding user-plane
traffic.

```
                       MAG                      LMA
                   +--------+               +--------+
  +------+         | MAG-CP |---------------| LMA-CP |       _----_
  |  MN  |         |        |    PMIPv6     |        |     _(      )_
  |      |---- +--------+               +--------+  ===( Internet )
  +------+         :                         :         (_      _)
                   +--------+               +--------+     '----'
                   | MAG-UP |---------------| LMA-UP |
                   |        |  GRE/IP-in-IP |        |
                   +--------+    /UDP       +--------+
```
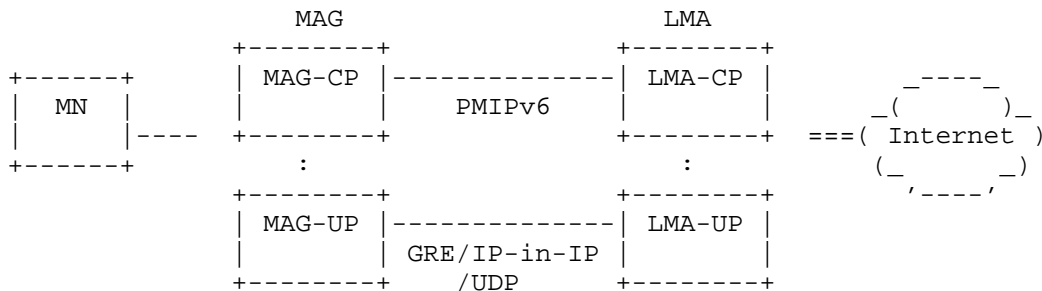
MN: Mobile Node
CP: Control Plane
UP: User Plane

        Figure 1: Functional Separation of the Control and User Plane

[RFC6463] and [RFC6275] enable separating the control and user plane
in the MAG. In particular, [RFC6463] defines the Alternate IPv4
Care-of Address option, and [RFC6275] defines an Alternate Care-of
Address option for IPv6. The MAG may provide an Alternate Care-of
Address in the PBU, and if the LMA supports this option, then a
bidirectional tunnel is set up between the LMA address and the MAG's
Alternate Care-of Address. However, these documents do not specify a
corresponding option for the LMA to provide an alternate tunnel
endpoint address to the MAG.

This specification therefore defines a new mobility option that
enables a local mobility anchor to provide an alternate LMA address
to be used for the bidirectional tunnel between the MAG and LMA, as
shown in Figure 1.

The LMA control-plane and the LMA user-plane functions are typically
deployed on the same IP node, and in such a scenario, the interface
between these functions is internal to the implementation.
Deployments may also choose to deploy the LMA control-plane and the
LMA user-plane functions on separate IP nodes. In such deployment
models, there needs to be a protocol interface between these two
functions, but that is outside the scope of this document. Possible
options for such an interface include OpenFlow
[OpenFlow-Spec-v1.4.0], Forwarding and Control Element Separation
(ForCES) [RFC5810], use of routing infrastructure [STATELESS-UPLANE],
and vendor-specific approaches. This specification does not mandate
a specific protocol interface and views this interface as a generic
interface relevant more broadly for many other protocol systems in
addition to Proxy Mobile IPv6. When the LMA control-plane and the
LMA user-plane functions are deployed on separate IP nodes, the
requirement related to user-plane address anchoring (specified in

   Section 5.6.2 of [RFC5213] and Section 3.1.3 of [RFC5844]) must be
   met by the node hosting the LMA user-plane functionality. The LMA
   user-plane node must be a topological anchor point for the IP
   address/prefixes allocated to the mobile node.

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

   3GPP terms can be found in [RFC6459]. Other mobility-related terms
   used in this document are to be interpreted as defined in [RFC5213]
   and [RFC5844]. Additionally, this document uses the following terms:

   IP-in-IP

      IP-within-IP Encapsulation [RFC2473] [RFC4213].

   GRE

      Generic Routing Encapsulation [RFC1701].

   UDP Encapsulation

      Encapsulation mode based on UDP transport specified in [RFC5844].

   LMA Control-Plane Address (LMA-CPA)

      The IP address on the LMA that is used for sending and receiving
      control-plane traffic from the MAG.

   LMA User-Plane Address (LMA-UPA)

      The IP address on the LMA that is used for sending and receiving
      user-plane traffic from the MAG.

   MAG Control-Plane Address (MAG-CPA)

      The IP address on the MAG that is used for sending and receiving
      control-plane traffic from the LMA.

MAG User-Plane Address (MAG-UPA)

> The IP address on the MAG that is used for sending and receiving
> user-plane traffic from the LMA. This address is also referred to
> as the Alternate Care-of Address.

3. Additional Fields in Conceptual Data Structures

To support the capability specified in this document, the conceptual
Binding Update List entry data structure maintained by the LMA and
the MAG is extended with the following additional fields:

o The IP address of the LMA that carries user-plane traffic.

o The IP address of the LMA that handles control-plane traffic.

4. LMA User-Plane Address Mobility Option

The LMA User-Plane Address mobility option is a new mobility header
option defined for use with PBU and PBA messages exchanged between
the LMA and the MAG. This option is used for notifying the MAG about
the LMA's user-plane IPv6 or IPv4 address. There can be zero, one,
or two instances of the LMA User-Plane Address mobility option
present in the message. When two instances of the option are
present, one instance of the option must be for IPv4 transport, and
the other instance must be for IPv6 transport.

The LMA User-Plane Address mobility option has an alignment
requirement of 8n+2. Its format is as shown in Figure 2:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |    Length     |            Reserved           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                                                               +
|                                                               |
.                                                               .
+                   LMA User-Plane Address                      +
|                                                               |
+                                                               +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
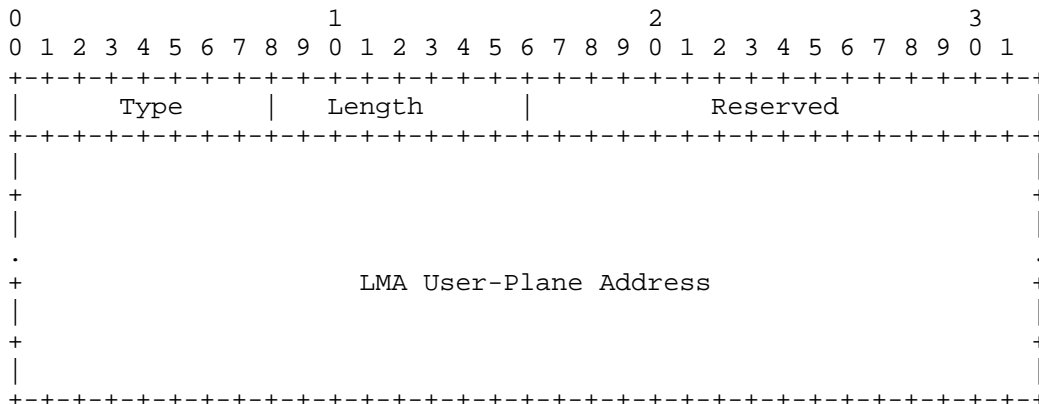
Figure 2: LMA User-Plane Address Mobility Option Format

Type

   59

Length

   An 8-bit, unsigned integer indicating the length of the option in
   octets, excluding the Type and Length fields.

Reserved

   This field is unused in this specification. The value MUST be set
   to zero (0) by the sender and MUST be ignored by the receiver.

LMA User-Plane Address

   Contains the 32-bit IPv4 address or the 128-bit IPv6 address of
   the LMA user plane. When the LMA User-Plane Address mobility
   option is included in a PBU message, this field can be a zero-
   length field, or it can have a value of ALL_ZERO, with all bits in
   the 32-bit IPv4 address or the 128-bit IPv6 address set to zero.

When including the LMA User-Plane Address mobility option in the PBU,
the MAG must apply the following rules:

o When using IPv4 transport for the user plane, the IP address field
   in the option MUST be either a zero-length field or a 4-octet
   field with ALL_ZERO value.

o When using IPv6 transport for the user plane, the IP address field
   in the option MUST be either a zero-length field or a 16-octet
   field with ALL_ZERO value.

When the LMA includes the LMA User-Plane Address mobility option in
the PBA, the IP address field in the option MUST be set to the LMA's
IPv4 or IPv6 address carrying user-plane traffic.

o When using IPv4 transport for the user plane, the IP address field
   in the option is the IPv4 address carrying user-plane traffic.

o When using IPv6 transport for the user plane, the IP address field
   in the option is the IPv6 address carrying user-plane traffic.

The encapsulation mode that will be chosen for the user plane between
the MAG and the LMA has to based on the considerations specified in
[RFC5213] and [RFC5844].

5. Protocol Configuration Variable

   This specification defines the following configuration variable,
   which must be configurable (e.g., by the system management) on the
   LMA and MAG mobility entities. The configured value for this
   protocol variable MUST survive server reboots and service restarts
   and MUST be the same for every LMA and MAG in the network domain
   supporting PMIPv6.

   Domain-wide-LMA-UPA-Support

        This variable indicates whether or not all the mobility
        entities in the PMIPv6 domain support the LMA User-Plane
        Address mobility option.

        When this variable on the MAG is set to zero (0), the MAG MUST
        indicate whether or not it supports this feature by including
        the LMA User-Plane Address mobility option in the PBU. If the
        option is not present in the PBU, the LMA SHALL disable this
        feature for the mobility session corresponding to the PBU.

        Setting this variable to one (1) on the MAG indicates that
        there is domain-wide support for this feature and the MAG is
        not required to include the LMA User-Plane Address mobility
        option in the PBA. In this case, the MAG MAY choose not to
        include the LMA User-Plane Address mobility option in the PBU.

        When this variable on the LMA is set to zero (0), the LMA MUST
        NOT include the LMA User-Plane Address mobility option in the
        PBA unless the MAG has indicated support for this feature by
        including the LMA User-Plane Address mobility option in the PBU
        message.

        Setting this variable to one (1) on the LMA indicates that
        there is domain-wide support for this feature and the LMA
        SHOULD choose to include this LMA User-Plane Address mobility
        option in the PBA even if the option is not present in the PBU
        message.

        On both the LMA and the MAG, the default value for this
        variable is zero (0). This implies that the default behavior
        of a MAG is to include this option in the PBU, and the default
        behavior of an LMA is to include this option in a PBA only if
        the option is present in the PBU.

6. IANA Considerations

   This specification defines a new mobility header option -- the LMA
   User-Plane Address mobility option. The format of this option is
   described in Section 4. The Type value 59 for this mobility option
   has been allocated by IANA in the "Mobility Options" registry at
   <http://www.iana.org/assignments/mobility-parameters>.

7. Security Considerations

   The Proxy Mobile IPv6 specification [RFC5213] requires the signaling
   messages between the MAG and the LMA to be protected using end-to-end
   security association(s) offering integrity and data origin
   authentication. The Proxy Mobile IPv6 specification also requires
   IPsec [RFC4301] to be a mandatory-to-implement security mechanism.

   This document specifies an approach where the control-plane and user-
   plane functions of the MAG and LMA are separated and hosted on
   different IP nodes. In such deployment models, the nodes hosting
   those respective control-plane functions still have to meet the
   [RFC5213] security requirement listed above; specifically, the Proxy
   Mobile IPv6 signaling messages exchanged between these entities MUST
   be protected using end-to-end security association(s) offering
   integrity and data origin authentication. Furthermore, IPsec is a
   mandatory-to-implement security mechanism for the nodes hosting the
   control-plane function of the MAG and LMA. Additional documents may
   specify alternative security mechanisms for securing Proxy Mobile
   IPv6 signaling messages. The mobility entities in a Proxy Mobile
   IPv6 domain can enable a specific security mechanism based on either
   (1) static configuration or (2) dynamic negotiation (using any
   standard security negotiation protocols).

   As per the Proxy Mobile IPv6 specification, the use of IPsec for
   protecting the mobile node's user-plane traffic is optional. This
   specification keeps the same requirement and therefore requires the
   nodes hosting the user-plane functions of the MAG and the LMA to have
   IPsec as a mandatory-to-implement security mechanism but make the use
   of IPsec optional for user-plane traffic protection.

   The LMA User-Plane Address mobility option defined in this
   specification is for use in PBU and PBA messages. This option is
   carried like any other mobility header option as specified in
   [RFC5213]. Therefore, it inherits security guidelines from
   [RFC5213].

The IP address of the LMA user plane (the LMA-UPA), provided within
the LMA User-Plane Address mobility option, MUST be a valid address
under the administrative control associated with the LMA functional
block.

If the LMA user-plane and the LMA control-plane functions are hosted
in different entities, any control messages between these two
entities containing the LMA User-Plane Address mobility option MUST
be protected using end-to-end security association(s) offering
integrity and data origin authentication.

8. References

8.1. Normative References

   [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate
              Requirement Levels", BCP 14, RFC 2119, March 1997,
              <http://www.rfc-editor.org/info/rfc2119>.

   [RFC4301] Kent, S. and K. Seo, "Security Architecture for the
              Internet Protocol", RFC 4301, December 2005,
              <http://www.rfc-editor.org/info/rfc4301>.

   [RFC5213] Gundavelli, S., Leung, K., Devarapalli, V., Chowdhury, K.,
              and B. Patil, "Proxy Mobile IPv6", RFC 5213, August 2008,
              <http://www.rfc-editor.org/info/rfc5213>.

   [RFC5844] Wakikawa, R. and S. Gundavelli, "IPv4 Support for Proxy
              Mobile IPv6", RFC 5844, May 2010,
              <http://www.rfc-editor.org/info/rfc5844>.

8.2. Informative References

   [MOBILE-SEPARATION]
              Wakikawa, R., Matsushima, S., Patil, B., Chen, B.,
              Joachimpillai, D., and H. Deng, "Requirements and use
              cases for separating control and user planes in mobile
              network architectures", Work in Progress,
              draft-wakikawa-req-mobile-cp-separation-00, November 2013.

   [OpenFlow-Spec-v1.4.0]
              Open Networking Foundation, "OpenFlow Switch
              Specification, Version 1.4.0", October 2013.

   [RFC1701] Hanks, S., Li, T., Farinacci, D., and P. Traina, "Generic
              Routing Encapsulation (GRE)", RFC 1701, October 1994,
              <http://www.rfc-editor.org/info/rfc1701>.

   [RFC2473] Conta, A. and S. Deering, "Generic Packet Tunneling in
              IPv6 Specification", RFC 2473, December 1998,
              <http://www.rfc-editor.org/info/rfc2473>.

   [RFC4213] Nordmark, E. and R. Gilligan, "Basic Transition Mechanisms
              for IPv6 Hosts and Routers", RFC 4213, October 2005,
              <http://www.rfc-editor.org/info/rfc4213>.

   [RFC5810] Doria, A., Hadi Salim, J., Haas, R., Khosravi, H., Wang,
              W., Dong, L., Gopal, R., and J. Halpern, "Forwarding and
              Control Element Separation (ForCES) Protocol
              Specification", RFC 5810, March 2010,
              <http://www.rfc-editor.org/info/rfc5810>.

   [RFC6275] Perkins, C., Johnson, D., and J. Arkko, "Mobility Support
              in IPv6", RFC 6275, July 2011,
              <http://www.rfc-editor.org/info/rfc6275>.

   [RFC6459] Korhonen, J., Soininen, J., Patil, B., Savolainen, T.,
              Bajko, G., and K. Iisakkila, "IPv6 in 3rd Generation
              Partnership Project (3GPP) Evolved Packet System (EPS)",
              RFC 6459, January 2012,
              <http://www.rfc-editor.org/info/rfc6459>.

   [RFC6463] Korhonen, J., Gundavelli, S., Yokota, H., and X. Cui,
              "Runtime Local Mobility Anchor (LMA) Assignment Support
              for Proxy Mobile IPv6", RFC 6463, February 2012,
              <http://www.rfc-editor.org/info/rfc6463>.

   [STATELESS-UPLANE]
              Matsushima, S. and R. Wakikawa, "Stateless user-plane
              architecture for virtualized EPC (vEPC)", Work in
              Progress, draft-matsushima-stateless-uplane-vepc-03,
              July 2014.

Authors' Addresses

   Ryuji Wakikawa
   Softbank Mobile
   1-9-1, Higashi-Shimbashi, Minato-Ku
   Tokyo 105-7322
   Japan

   EMail: ryuji.wakikawa@gmail.com

   Rajesh S. Pazhyannur
   Cisco
   170 West Tasman Drive
   San Jose, CA 95134
   United States

   EMail: rpazhyan@cisco.com

   Sri Gundavelli
   Cisco
   170 West Tasman Drive
   San Jose, CA 95134
   United States

   EMail: sgundave@cisco.com

   Charles E. Perkins
   Futurewei Inc.
   2330 Central Expressway
   Santa Clara, CA 95050
   United States

   EMail: charliep@computer.org