Network Working Group F. Templin, Ed.
Internet-Draft Boeing Research & Technology
Intended status: Informational November 10, 2014
Expires: May 14, 2015

# AERO Minimal Encapsulation
# draft-templin-aeromin-00.txt

Abstract

Asymmetric Extended Route Optimization (AERO) specifies both a control messaging facility and an encapsulation format for managing tunnels over an enterprise network or other Internetwork. Although AERO can operate with any tunnel encapsulation format, the base document considers IP-in-UDP-in-IP encapsulation as the default. This document presents a minimal encapsulation format for AERO for use when a UDP header is not needed.

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Table of Contents



## 1. Introduction

Asymmetric Extended Route Optimization (AERO) [I-D.templin-aerolink] specifies both a control messaging facility and an encapsulation format for forwarding Internet Protocol (IP) packets [RFC0791] [RFC2460] over an enterprise network or other Internetwork through a process known as tunneling. Although AERO can operate with any tunnel encapsulation format, the base document specifies the insertion of a User Datagram Protocol (UDP) header [RFC0768] with port 8060 between the inner and outer IP headers, i.e., as IP-in-UDP-in-IP. This document presents a minimal encapsulation format for AERO for use when a UDP header is not needed.

In its minimal form, AERO can use direct IP-in-IP encapsulation [RFC2003][RFC2473][RFC4213] with no intermediate layer between the inner and outer IP headers for interior routing and addressing services. The encapsulation is therefore only differentiated from other IP-in-IP tunnel types through the application of AERO control messaging facilities.

However, the tunnel fragmentation required by AERO to support a guaranteed minimum 1500 bytes cannot be accomplished by inserting an IPv6 Fragment Header immediately following the UDP header, since the UDP header is not included for minimal encapsulation. Instead, the IPv6 fragment header is inserted directly between the inner and outer IP headers when needed, i.e., even if the outer header is IPv4. The IPv6 Fragment Header is identified to the outer IP layer by its IP protocol number, and the Next Header field in the IPv6 Fragment Header identifies the inner IP header version.

## 2. Minimal Encapsulation Format

Figure 1 shows the AERO minimal encapsulation format before any fragmentation is applied:

```
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+               +-+-+-+-+-+-+-+-+-+-+-+-+-
+-+-+-+-+-+
     |       Outer IPv4 Header       |                 |        Outer IPv6
Header      |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+               +-+-+-+-+-+-+-+-+-+-+-+-+-
+-+-+-+-+-+
     |IPv6 Fragment Header (optional)|                 |IPv6 Fragment Header
(optional)|
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+               +-+-+-+-+-+-+-+-+-+-+-+-+-
+-+-+-+-+-+
     |        Inner IP Header        |                 |         Inner IP
Header       |                                                     |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+               +-+-+-+-+-+-+-+-+-+-+-+-+-
+-+-+-+-+-+
     |                               |
|                               |
     ~                               ~
~                               ~
     ~      Inner Packet Body        ~                 ~       Inner Packet
Body       ~
     ~                               ~
~                               ~
     |                               |
|                               |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+               +-+-+-+-+-+-+-+-+-+-+-+-+-
+-+-+-+-+-+

      Minimal Encapsulation in IPv4                     Minimal Encapsulation in
IPv6
```

Figure 1: Minimal Encapsulation Format

## 3. When to Insert the IPv6 Fragment Header

The IPv6 Fragment Header is inserted whenever the AERO tunnel ingress needs to apply fragmentation to accommodate packets no larger than 1500 bytes. Fragmentation is performed on the inner packet while encapsulating each inner packet fragment in identical outer IP and IPv6 Fragment Headers. Fragmentation therefore follows the same procedure as for the case when a UDP header is included, which follows the same procedure as for standard IPv6 fragmentation.

The IPv6 Fragment Header can also be inserted in order to include a coherent Identification value with each packet, e.g., to aid in Duplicate Packet Detection (DPD).  In this way, networking devices can cache the Identification values of recently-seen packets and use the cached values to determine whether a newly-arrived packet is in fact a duplicate.

Finally, the Identification value within each packet could provide a rough indicator of packet reordering, e.g., in cases when the tunnel egress wishes to discard packets that are grossly out of order.

## 4. Considerations for Using Minimal Encapsulation

Minimal encapsulation is preferred in environments where UDP encapsulation would add unnecessary overhead. For example, certain low-bandwidth wireless data links may benefit from an 8-byte-per-packet overhead reduction. This is not likely to be a prime consideration for many modern wireless data links nor for most modern wired-line data links.

UDP encapsulation can traverse network paths that are inaccessible to minimal encapsulation, e.g., for crossing Network Address Translators (NATs). More and more, network middleboxes are also being configured to discard packets that include anything other than a well-known IP protocol such as UDP and TCP. It may therefore be necessary to consider the potential for middlebox filtering before enabling minimal encapsulation in a given environment.

Evidence seems to suggest that IPv6 fragmentation does not work along all paths, since well-meaning network middleboxes may consider it as an attack.

## 5. IANA Considerations

This document introduces no IANA considerations.

## 6. Security Considerations

Security considerations are discussed in the base AERO specification [I-D.templin-aerolink].

## 7. Acknowledgements

TBD

## 8. References

### 8.1. Normative References

[RFC0768] Postel, J., "User Datagram Protocol", STD 6, RFC 768, August 1980.

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[RFC4213] Nordmark, E. and R. Gilligan, "Basic Transition Mechanisms for IPv6 Hosts and Routers", RFC 4213, October 2005.

### 8.2. Informative References

[I-D.templin-aerolink] Templin, F., "Transmission of IP Packets over AERO Links", draft-templin-aerolink-46 (work in progress), October 2014.

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