Internet Draft
<draft-ietf-ospf-transition-to-ospfv3-01.txt>
Intended Status: Standards Track

I. Chen
Ericsson
A. Lindem
Cisco
R. Atkinson
Consultant

Expires in 6 months
May 11, 2015

OSPFv3 over IPv4 for IPv6 Transition
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Status of this Memo

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Abstract

This document defines a mechanism to use IPv4 to transport OSPFv3 packets, in order to facilitate transition from IPv4-only to IPv6 and dual-stack within a routing domain. Using OSPFv3 over IPv4 with the existing OSPFv3 Address Family extension can simplify transition from an OSFPv2 IPv4-only routing domain to an OSPFv3 dual-stack routing domain.

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1. Introduction

To facilitate transition from IPv4 [RFC791] to IPv6 [RFC2460], dual-stack or IPv6 routing protocols should be gradually deployed. Dual-stack routing protocols, such as Border Gateway Protocol [RFC4271], have an advantage during the transition, because both IPv4 and IPv6 topologies can be transported using either IPv4 or IPv6. Some IPv4-specific and IPv6-specific routing protocols share enough similarities in their protocol packet formats and protocol signaling that it is trivial to deploy an initial IPv6 routing domain by carrying the routing protocol over IPv4 initially, thereby allowing IPv6 routing domains be deployed and tested before decommissioning IPv4 and moving to an IPv6-only network.

In the case of the Open Shortest Path First (OSPF) interior gateway routing protocol (IGP), OSPFv2 [RFC2328] is the IGP deployed over IPv4, while OSPFv3 [RFC5340] is the IGP deployed over IPv6. OSPFv3 further supports multiple address families [RFC5838], including both the IPv6 unicast address family and the IPv4 unicast address family. Consequently, it is possible to deploy OSPFv3 over IPv4 without any changes either to OSPFv3 or to IPv4. During the transition to IPv6, future OSPF extension can focus on OSPFv3 and OSPFv2 can move into maintenance mode.

This document specifies how to use IPv4 packets to transport OSPFv3 packets. The mechanism takes advantage of the fact that OSPFv2 and OSPFv3 share the same IP protocol number, 89. Additionally, the OSPF packet header for both OSPFv2 and OSPFv3 places the OSPF header version (i.e., the field that distinguishes an OSPFv2 packet from an OSPFv3 packet) in the same location.

This document does not attempt to connect an IPv4 topology and an IPv6 topology that are not congruent. In normal operation, it is expected that the IPv4 topology within the OSPF domain will be congruent with the IPv6 topology of that OSPF domain. In such cases,

it is expected either that all OSPFv3 packets will be transported over IPv4 or that all OSPFv3 packets will be transported over IPv6.

If the IPv4 topology and IPv6 topology are not identical, the most likely cause is that some parts of the network deployment have not yet been upgraded to support both IPv4 and IPv6. In situations where the IPv4 deployment is a proper superset of the IPv6 deployment, it is expected that OSPFv3 packets would be transported over IPv4, until the rest of the network deployment is upgraded to support IPv6 in addition to IPv4. In situations where the IPv6 deployment is a proper superset of the IPv4 deployment, it is expected that OSPFv3 would be transported over IPv6.

Throughout this document, OSPF is used when the text applies to both OSPFv2 and OSPFv3. OSPFv2 or OSPFv3 is used when the text is specific to one version of the OSPF protocol. Similarly, IP is used when the text describes either version of the Internet protocol. IPv4 or IPv6 is used when the text is specific to a single version of the protocol.

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].

3. Encapsulation in IPv4

Unlike 6to4 encapsulation [RFC3056] that tunnels IPv6 traffic through an IPv4 network, an OSPFv3 packet can be directly encapsulated within an IPv4 packet as the payload, without the IPv6 packet header, as illustrated in Figure 1. For OSPFv3 transported over IPv4, the IPv4 packet has an IPv4 protocol type of 89, denoting that the payload is an OSPF packet. The payload of the IPv4 packet consists of an OSPFv3 packet, beginning with the OSPF packet header with the OSPF version number set to 3.

An OSPFv3 packet followed by an OSPF link-local signaling (LLS) extension data block [RFC5613] encapsulated in an IPv4 packet is illustrated 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  ^
|   4   |  IHL  |Type of Service|          Total Length         |  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |
|         Identification        |Flags|      Fragment Offset    |  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Time to Live | Protocol 89   |         Header Checksum       | IPv4
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ Header
|                       Source Address                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |
|                    Destination Address                        |  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |
|                    Options                    |    Padding    |  v
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  ^
|       3       |     Type      |         Packet length         |  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Router ID                             | OSPFv3
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ Header
|                          Area ID                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |
|          Checksum             |  Instance ID  |      0        |  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  v
|                        OSPFv3 Body ...                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 1: An IPv4 packet encapsulating an OSPFv3 packet.

```
                      +---------------+
                      | IPv4 Header   |
                      +---------------+
                      | OSPFv3 Header |
                      |...............|
                      |               |
                      | OSPFv3 Body   |
                      |               |
                      +---------------+
                      |               |
                      | LLS Data      |
                      |               |
                      +---------------+
```

Figure 2: The IPv4 packet encapsulating an OSPFv3 packet with
a trailing OSPF link-local signaling data block.

3.1. Source Address

For OSPFv3 over IPv4, the source address is the IPv4 interface address for the interface over which the packet is transmitted. All OSPFv3 routers on the link MUST share the same IPv4 subnet for IPv4 transport to function correctly.

3.2. Destination Address

As defined in OSPFv2, the IPv4 destination address of an OSPF protocol packet is either an IPv4 multicast address or the IPv4 unicast address of an OSPFv2 neighbor. Two well-known link-local multicast addresses are assigned to OSPFv2, the AllSPFRouters address (224.0.0.5) and the AllDRouters address (224.0.0.6). The multicast address used depends on the OSPF packet type, the OSPF interface type, and the OSPF router's role on multi-access networks.

Thus, for an OSPFv3 over IPv4 packet to be sent to AllSPFRouters, the destination address field in the IPv4 packet should be 224.0.0.5. For an OSPFv3 over IPv4 packet to be sent to AllDRouters, the destination address field in the IPv4 packet should be 224.0.0.6.

When an OSPF router sends a unicast OSPF packet over a connected interface, the destination of such an IP packet is the address assigned to the receiving interface. Thus, a unicast OSPFv3 packet transported in an IPv4 packet would specify the OSPFv3 neighbor's IPv4 address as the destination address.

3.3. Operation over Virtual Link

When an OSPF router sends an OSPF packet over a virtual link, the receiving router is a router which is not directly connected to the sending router. Thus, the destination IP address of the IP packet must be a reachable unicast IP address of the receiving router. Because IPv6 is the presumed Internet protocol and an IPv4 destination is not routable, the OSPFv3 address family extension [RFC5838] specifies that only IPv6 address family virtual links are supported.

As illustrated in Figure 1, this document specifies OSPFv3 transport over IPv4. As a result, an IPv4 packet in which the destination field is a unicast IPv4 address assigned to the virtual router is routable, and OSPFv3 virtual links in IPv4 unicast address families can be supported. Hence, the restriction in Section 2.8 of RFC 5838 [RFC5838] is removed. If IPv4 transport, as specified herein, is used for IPv6 address families, virtual

links cannot be supported. Hence, it is RECOMMENDED to use the IP transport matching the address family in OSPF routing domains requiring virtual links.

4. IPv4-only Use Case

OSPFv3 only requires IPv6 link-local addresses to establish a routing domain, and does not require IPv6 global-scope addresses to establish a routing domain. However, IPv6 over Ethernet [RFC2464] uses a different EtherType (0x86dd) from IPv4 (0x0800) and also from the Address Resolution Protocol (ARP) (0x0806) [RFC826] that is used with IPv4.

Some existing deployed link-layer equipment only supports IPv4 and ARP. Such equipment contains hardware filters keyed on the EtherType field of the Ethernet frame to filter which frames will be accepted into that link-layer equipment. Because IPv6 uses a different EtherType, IPv6 framing for OSPFv3 won't work with that equipment. In other cases, PPP might be used over a serial interface, but again only IPv4 over PPP might be supported over that interface. It is hoped that equipment with such limitations will be replaced eventually.

In some locations, especially locations with less communications infrastructure, satellite communications (SATCOM) is used to reduce deployment costs for data networking. SATCOM often has lower cost to deploy than running new copper or optical cables for long distances to connect remote areas. Also, in a wide range of locations including places with good communications infrastructure, Very Small Aperture Terminals (VSAT) often are used by banks and retailers to connect their stores to their main offices.

Some widely deployed VSAT equipment has either (A) Ethernet interfaces that only support Ethernet Address Resolution Protocol (ARP) and IPv4, or (B) serial interfaces that only support IPv4 and Point-to-Point Protocol (PPP) packets. Such deployments and equipment still can deploy and use OSPFv3 over IPv4 today, and then later migrate to OSPFv3 over IPv6 after equipment is upgraded or replaced. This can have lower operational costs than running OSPFv2 and then trying to make a flag-day switch to running OSPFv3. By running OSPFv3 over IPv4 now, the eventual transition to dual-stack, and then to IPv6-only can be optimized.

5. Security Considerations

As described in [RFC4552], OSPFv3 uses IPsec [RFC4301] for authentication and confidentiality. Consequently, an OSPFv3 packet transported within an IPv4 packet requires IPsec to provide

authentication and confidentiality. Further work such as [ipsecospf] would be required to support IPsec protection for OSPFv3 over IPv4 transport.

An optional OSPFv3 Authentication Trailer [RFC7166] also has been defined as an alternative to using IPsec. The calculation of the authentication data in the Authentication Trailer includes the source IPv6 address to protect an OSPFv3 router from Man-in-the-Middle attacks. For IPv4 encapsulation as described herein, the IPv4 source address should be placed in the first 4 octets of Apad followed by the hexadecimal value 0x878FE1F3 repeated (L-4)/4 times, where L is the length of hash measured in octet.

The processing of the optional Authentication Trailer is contained entirely within the OSPFv3 protocol. In other words, each OSPFv3 router instance is responsible for the authentication, without involvement from IPsec or any other IP layer function. Consequently, except for calculation of the value Apad, transporting OSPFv3 packets using IPv4 does not change the operation of the optional OSPFv3 Authentication Trailer.

6. IANA Considerations

No actions are required from IANA as result of the publication of this document.

7. References

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Authors' Addresses

I. Chen
Ericsson
Email: ing-wher.chen@ericsson.com

A. Lindem
Cisco
Email: acee@cisco.com

R. Atkinson
Consultant