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Transmission of IPv4 Packets over ISATAP Interfaces
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Abstract

The Intra-Site Automatic Tunnel Addressing Protocol (ISATAP) specifies a Non-Broadcast, Multiple Access (NBMA) interface type for the transmission of IPv6 packets over IPv4 networks using automatic

IPv6-in-IPv4 encapsulation. The original specifications make no provisions for the encapsulation and transmission of IPv4 packets, however. This document specifies a method for transmitting IPv4 packets over ISATAP interfaces.

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1. Introduction

The Intra-Site Automatic Tunnel Addressing Protocol (ISATAP) [RFC5214] specifies a Non-Broadcast, Multiple Access (NBMA) interface type for the transmission of IPv6 packets over IPv4 networks using automatic IPv6-in-IPv4 encapsulation. ISATAP interfaces therefore typically configure IPv6 addresses and prefixes, but they do not configure IPv4 addresses and prefixes. In typical implementations and deployments, an ISATAP interface therefore appears as an ordinary interface configured for IPv6 operation but with a null IPv4 configuration. This places an unnecessary limitation on the ISATAP domain of applicability.

ISATAP interfaces perform automatic IPv6-in-IPv4 encapsulation over a virtual IPv6 overlay that spans a region within a connected IPv4 routing topology (i.e., a "site") comprising ordinary IPv4 routers. ISATAP interfaces configure IPv6 link-local addresses that encapsulate an IPv4 address assigned to an underlying IPv4 interface within the IPv6 link-local prefix 'fe80::/10' as specified in [RFC5214], Sections 6 and 7. ISATAP interfaces may additionally configure IPv6 addresses from a non-link-local IPv6 prefix in exactly the same fashion. As a result, [RFC5214] extends the basic transition mechanisms specified in [RFC4213].

This document specifies mechanisms and operational practices that enable automatic IPv4-in-IPv4 encapsulation over ISATAP interfaces in the same manner as for IPv6-in-IPv4 encapsulation. As a result, this document also extends the IPv4-in-IPv4 tunneling mechanisms specified in [RFC2003]. These mechanisms are useful in a wide variety of enterprise network scenarios, e.g., as discussed in the RANGER [I-D.templin-ranger] and VET [I-D.templin-autoconf-dhcp] proposals.

The following sections specify IPv4 operation over ISATAP interfaces. A working knowledge of the IPv4 and IPv6 protocols [RFC0791] [RFC2460], IPv4-in-IPv4 encapsulation [RFC2003], and IPv6-in-IPv4 encapsulation [RFC4213][RFC5214] is assumed.

2. Terminology

The keywords MUST, MUST NOT, REQUIRED, SHALL, SHALL NOT, SHOULD, SHOULD NOT, RECOMMENDED, MAY, and OPTIONAL, when they appear in this document, are to be interpreted as described in [RFC2119].

3. ISATAP Interface Model

ISATAP interfaces use automatic IPv6-in-IPv4 encapsulation to span a

region within a connected IPv4 routing topology (i.e., a "site") in a single IPv6 hop. That is to say that the site comprises border nodes with ISATAP interfaces that forward IPv6-in-IPv4 packets across the site in a single IPv6 hop, and ordinary IPv4 routers between the border nodes that decrement the TTL in the outer IPv4 header. Border nodes that configure ISATAP interfaces within the same site therefore see each other as single-hop neighbors.

ISATAP interfaces are configured over one or more of the node's underlying IPv4 interfaces connected to the site. These underlying IPv4 interfaces configure site- or greater-scoped IPv4 addresses, and the underlying IPv4 interfaces of two "neighboring" ISATAP interfaces may be separated by many IPv4 hops within the site.

This specification simply extends the ISATAP interface model to also support IPv4-in-IPv4 encapsulation. When IPv4-in-IPv4 encapsulation is used, the ISATAP interface spans exactly the same underlying site as for IPv6-in-IPv4 encapsulation.

4. ISATAP Interface MTU

ISATAP interface MTU considerations are exactly as specified in [RFC4213], Section 3.2, and apply equally for both IPv6 and IPv4 operation.

5. IPv6 Operation

IPv6 operations over ISATAP interfaces are exactly as specified in [RFC5214].

6. IPv4 Operation

The following sections specify IPv4 operation over ISATAP interfaces:

6.1. ISATAP IPv4 Address Configuration

As for IPv6 operation, IPv4 operation requires that all ISATAP interfaces connected to the same site configure a unique Layer 3 IPv4 address ("L3ADDR") taken from a shared IPv4 subnet prefix. L3ADDR is used for next-hop determination, but it may also be used as the source address for packets that originate from the ISATAP interface itself.

When global-scoped communications are needed, or when a unique "name" for the ISATAP site is required (e.g., to distinguish it from other

ISATAP sites), L3ADDR is taken from a global-scoped IPv4 prefix (e.g., 192.0.2/24). Otherwise, it may be taken from a link-local-scoped IPv4 prefix (e.g., 169.254/16 [RFC3927]).

Methods for ensuring L3ADDR uniqueness are outside the scope of this document.

6.2. IPv4 Route Configuration

As for any IPv4 interface, IPv4 Forwarding Information Base (FIB) entries (i.e., IPv4 routes) are configured over ISATAP interfaces via either administrative or dynamic mechanisms.

Next hop addresses in FIB entries configured over an ISATAP interface correspond to the L3ADDR assigned to the ISATAP interface of a neighbor.

6.3. ISATAP Interface Determination

When the node's IPv4 layer has a packet to send, it performs an IPv4 FIB lookup to determine the outgoing ISATAP interface and the next-hop L3ADDR. The node then checks the packet length against the MTU configured on the ISATAP interface.

If the packet is no larger than the MTU, the node admits it into the ISATAP interface without fragmentation. If the packet is larger than the MTU, the node examines the "Don't Fragment (DF)" flag in the IPv4 header. If DF=1, it drops the packet and returns an ICMPv4 "fragmentation needed" message to the original source [RFC1191]; otherwise it fragments the packet using IPv4 fragmentation and admits each fragment into the ISATAP interface.

6.4. Next-Hop Resolution

When the node admits an IPv4 packet/fragment into the ISATAP interface, it resolves the next-hop L3ADDR into a next-hop Layer 2 address ("L2ADDR") which in reality is the IPv4 address of an underlying interface of the ISATAP neighbor which may be many IPv4 hops away. Methods for resolving the next-hop L3ADDR into a next-hop L2ADDR are through static table lookup or through some other means outside the scope of this document.

The node next performs an IPv4 FIB lookup on the next-hop L2ADDR to determine the correct underlying IPv4 interface. If the FIB lookup fails, the node drops the packet and returns an ICMPv4 "Destination Unreachable" message to the original source [RFC0792]; otherwise, it encapsulates the packet and submits it to the IPv4 layer as described below.

6.5. Encapsulation and Transmission

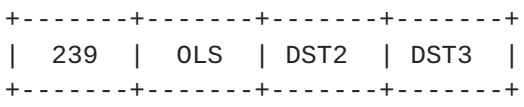
After performing the IPv4 FIB lookup on the next-hop L2ADDR, the node encapsulates the packet as specified in [RFC2003] with the IPv4 address of the underlying interface as the outer IPv4 source address and the next-hop L2ADDR as the outer IPv4 destination address. The node sets the DF flag in the outer IPv4 header according to Section 3.2 of [RFC4213]. The node also sets the IP protocol field in the outer IPv4 header to 4 (i.e., ip-protocol-4).

The node then submits the encapsulated packet to the IPv4 layer. The IPv4 layer fragments the packet if necessary, then forwards each fragment to the underlying IPv4 interface. The underlying IPv4 interface then performs address resolution on the outer IPv4 destination address (i.e., the next-hop L2ADDR) and submits the packet for transmission on the underlying link layer.

6.6. IPv4 Multicast Mapping

In many aspects, ISATAP is simply a unicast-only derivative of "6over4" [RFC2529]. For various reasons, however, ISATAP has seen practical wide-scale deployment while the 6over4 approach has been silently carried forward through ongoing research efforts. This specification extends the ISATAP interface model to support IPv4 multicast mapping in a manner that exactly parallels IPv6 multicast mapping in 6over4 (see: [RFC2529], Section 6). Indeed, the approach might more aptly be named as "4over4" were it not for the fact that the name "ISATAP" has already become ingrained in the widely published terminology.

IPv4 multicast mapping is available only on ISATAP interfaces configured over sites that support IPv4 multicast. For such sites, an IPv4 packet sent on an ISATAP interface with a multicast destination address DST MUST be encapsulated for transmission on an underlying IPv4 interface to the IPv4 multicast address of Organization-Local Scope using the mapping below. The mapped address SHOULD be taken from the block 239.193.0.0/16, a different sub-block of the Organization-Local Scope address block, or, if all of those are not available, from the expansion blocks defined in [RFC2365]. Note that when they are formed using the expansion blocks, they use only a /16 sized block.



DST2, DST3 last two bytes of IPv4 multicast address.

OLS from the configured Organization-Local Scope address block. SHOULD be 193, see [RFC2365] for details.

Figure 1: ISATAPv4 Multicast Mapping

No new IANA registration procedures are required for the above.

6.7. Recursive Encapsulation Avoidance

The node must take care in managing its IPv4 FIB table entries in order to avoid looping through recursive encapsulations.

7. IANA Considerations

There are no IANA considerations for this document.

8. Security Considerations

The security considerations specified in [RFC2003] apply equally to this document. The security considerations specified in ISATAP [RFC5214] and 6over4 [RFC2529] also apply, with the exception that ip-protocol-4 encapsulation is used instead of ip-protocol-41.

Updated tunnel security considerations are found in [I-D.ietf-v6ops-tunnel-security-concerns].

9. Acknowledgements

This work extends the ISATAP interface model, which has evolved through the insights of many contributers over the course of many decades.

10. References

10.1. Normative References

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Appendix A. Encapsulation Avoidance

In some instances, an ISATAP interface may be configured over a site in which all single-hop ISATAP neighbors are also known to be single-hop neighbors in the underlying site. In that case alone, if the next-hop L3ADDR and next-hop L2ADDR are both routable within the underlying site the ISATAP interface MAY avoid encapsulation and submit the unencapsulated packets directly to the IPv4 layer while using the next-hop L2ADDR (i.e., and not the next-hop L3ADDR) as the next hop.

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