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          IPv6 Multicast Address Format With Embedded IPv4 Multicast Address
              draft-ietf-mboned-64-multicast-address-format-02

Abstract

   This document specifies an extension to the IPv6 multicast addressing
   architecture to be used in the context of IPv4-IPv6 interconnection.
   In particular, this document defines an address format for IPv4-
   embedded IPv6 multicast addresses. This address format can be used
   for IPv4-IPv6 translation or encapsulation schemes.

   This document updates RFC4291.

Requirements Language

   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].

material or to cite them other than as "work in progress."

This Internet-Draft will expire on November 24, 2012.

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1. Introduction

   Various solutions (e.g., [I-D.ietf-softwire-mesh-multicast],
   [I-D.ietf-softwire-dslite-multicast]) have been proposed to allow
   access to IPv4 multicast content from hosts attached to IPv6-enabled
   domains. Even if these solutions have distinct applicability scopes
   (translation vs. encapsulation) and target different use cases, they
   all make use of specific IPv6 multicast addresses to embed an IPv4
   multicast address. Particularly, the IPv4-embedded IPv6 multicast
   address is used as a destination IPv6 address of multicast flows
   received from an IPv4-enabled domain and injected by the IPv4-IPv6
   Interconnection Function into an IPv6-enabled domain. It is also
   used to build an IPv6 multicast state (*, G6) or (S6, G6)
   corresponding to their (*, G4) or (S4, G4) IPv4 counter parts by the
   IPv4-IPv6 Interconnection Function. [I-D.ietf-mboned-v4v6-mcast-ps]
   provides more discussion about issues related to IPv4/IPv6 multicast.

   This document specifies an extension to the IPv6 multicast addressing
   architecture to be used in the context of IPv4-IPv6 interconnection.
   In particular, this document defines an address format for IPv4-
   embedded IPv6 multicast addresses. This address format can be used
   for IPv4-IPv6 translation or encapsulation schemes.

   This document updates [RFC4291]. A new M-bit is defined; if set to
   "1", it indicates an IPv4 multicast address is embedded in the low-
   order 32 bits of the IPv6 multicast address. Appendix A.1 enumerates
   the arguments in favor of defining an address format while
   Appendix A.2 discusses why identifying an IPv4-embedded IPv6
   multicast address is needed.

   This specification can be used in conjunction with other extensions
   such as building unicast prefix-based multicast IPv6 address
   [RFC3306] or embedding the rendezvous point [RFC3956].

   This document is a companion document to [RFC6052] which focuses
   exclusively on IPv4-embedded IPv6 unicast addresses.

   Details about design choices are documented in Appendix A.

2. Terminology

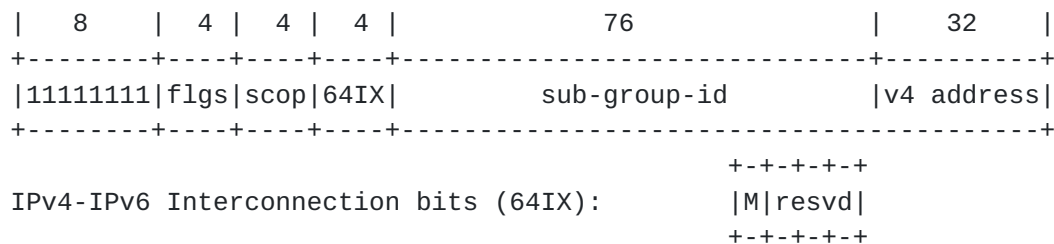   This document makes use of the following terms:

   o IPv4-embedded IPv6 multicast address: denotes a multicast IPv6
      address which includes in 32 bits an IPv4 address. Two types of
      IPv6 addresses are defined that carry an IPv4 address in the low-
      order 32 bits of the address. The format to build such addresses

is defined in Section 3 for Any Source Multicast (ASM) mode and
Section 4 for Source Specific Multicast (SSM) mode.

o Multicast Prefix64 (or MPREFIX64 for short) refers to an IPv6
   multicast prefix to be used to construct IPv4-embedded IPv6
   multicast addresses. This prefix is used to build an IPv4-
   embedded IPv6 multicast address as defined in Section 8.
   Section 8 specifies also how to extract an IPv4 address from an
   IPv4-embedded IPv6 multicast address.

o ASM_MPREFIX64: denotes a multicast Prefix64 used in ASM mode. It
   follows the format described in Section 3.

o SSM_MPREFIX64: denotes a multicast Prefix64 used in SSM mode. It
   follows the format described in Section 4.

o IPv4-IPv6 Interconnection Function: refers to a function which is
   enabled in a node interconnecting an IPv4-enabled domain with an
   IPv6-enabled one. It can be located in various places of the
   multicast network. Particularly, in terms of multicast control
   messages, it can be an IGMP/MLD Interworking Function or an IPv4-
   IPv6 PIM Interworking Function. An IPv4-IPv6 Interconnection
   Function is configured with one or two MPREFIX64s.

3. IPv4-Embedded IPv6 Multicast Address Format: ASM Mode

   To meet the requirements listed in Appendix A.4, the IPv6 multicast
   address format defined in [RFC4291] is modified to enclose an IPv4
   multicast address. Figure 1 shows the modified address format when
   ASM mode is used.

   | 8 | 4 | 4 | 4 | 76 | 32 |
    +--------+----+----+----+-------------------------------+----------+
    |11111111|flgs|scop|64IX| sub-group-id |v4 address|
    +--------+----+----+----+-------------------------------+----------+
                                          +-+-+-+-+
     IPv4-IPv6 Interconnection bits (64IX): |M|resvd|
                                          +-+-+-+-+
    "resvd" are reserved bits.

       Figure 1: IPv4-Embedded IPv6 Multicast Address Format: ASM Mode
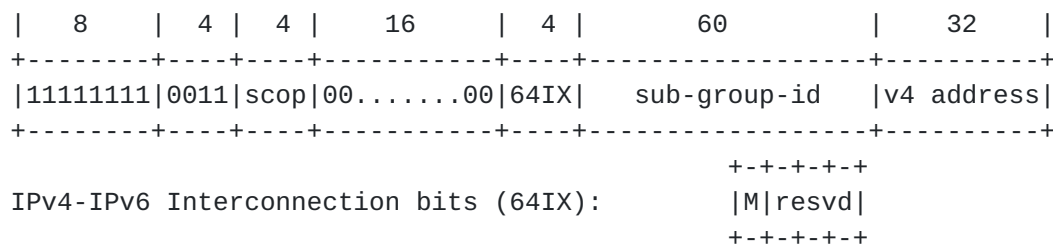
   The description of the fields is as follows:
   o "flgs" and "scop" fields are defined in [RFC4291].

o 64IX field (IPv4-IPv6 interconnection bits): The first bit is the
   M-bit. When "M-bit" is set to 1, it indicates that a multicast
   IPv4 address is embedded in the low-order 32 bits of the multicast
   IPv6 address. All the remaining bits are reserved and MUST be set
   to 0.
o sub-group-id: This field is configurable according to local
   policies (e.g., enable embedded-RP) of the entity managing the
   IPv4-IPv6 Interconnection Function. This field MUST follow the
   recommendations specified in [RFC3306] if unicast-based prefix is
   used or the recommendations specified in [RFC3956] if embedded-RP
   is used. The default value is all zeros.
o The low-order 32 bits MUST include an IPv4 multicast address when
   the M-bit is set to 1. The enclosed IPv4 multicast address SHOULD
   NOT be in 232/8 range.

4. IPv4-Embedded IPv6 Multicast Address Format: SSM Mode

As mentioned in Appendix A.4, any IPv4-embedded IPv6 address used in
SSM mode MUST be part of ff3x::/32 [RFC4607]. Figure 2 describes the
format of the IPv6 multicast address to be used to enclose an IPv4
multicast address.

```
 |   8    | 4 | 4 |    16     | 4 |       60         |    32    |
 +--------+----+----+----------+----+-----------------+----------+
 |11111111|0011|scop|00.......00|64IX|   sub-group-id   |v4 address|
 +--------+----+----+----------+----+-----------------+----------+
                                       +-+-+-+-+-+
  IPv4-IPv6 Interconnection bits (64IX):      |M|resvd|
                                       +-+-+-+-+-+
   "resvd" are reserved bits.
```

   Figure 2: IPv4-Embedded IPv6 Multicast Address Format: SSM Mode

The description of the fields is as follows:

o Flags MUST be set to 0011.
o "scop" is defined in [RFC4291].
o 64IX field (IPv4-IPv6 interconnection bits): Same meaning as
   Section 3.
o sub-group-id: The default value is all zeros.
o The low-order 32 bits MUST include an IPv4 multicast address when
   the M-bit is set to 1. The embedded IPv4 address SHOULD be in the
   232/8 range [RFC4607].

5. Textual Representation

The embedded IPv4 address in an IPv6 multicast address is included in
the last 32 bits; therefore dotted decimal notation can be used.

6. Multicast PREFIX64

For the delivery of the IPv4-IPv6 multicast interconnection services,
a dedicated multicast prefix denoted as MPREFIX64 should be
provisioned (e.g., using NETCONF or
[I-D.ietf-softwire-multicast-prefix-option]) to any function
requiring to build an IPv4-embedded IPv6 multicast address based on
an IPv4 multicast address. MPREFIX64 can be of ASM or SSM type.
When both modes are used, two prefixes are required to be
provisioned.

The structure of the MPREFIX64 follows the guidelines specified in
Section 3 for the ASM mode and Section 4 when SSM mode is used.

The length of MPREFIX64 MUST be /96 (as shown in Figure 3).

The format of the MPREFIX64 should follow what is specified in
[RFC3306] and [RFC3956] if corresponding mechanisms are used.

   The format specified in Section 3 uses some reserved bits defined
   in [RFC3306] and [RFC3956]: the first of the reserved bits now has
   a meaning, while the remaining bits MUST be set to 0.

   ASM Mode:

```
   |   8    | 4 | 4 | 4 |              76              |   32     |
   +--------+----+----+----+----------------------------+----------+
   |11111111|flgs|scop|64IX|        sub-group-id        |v4 address|
   +--------+----+----+----+----------------------------+----------+
   |                                                    |          |
   v                                                    v          v
   +----------------------------------------------------+----------+
   |                ASM_MPREFIX64                       |v4 address|
   +----------------------------------------------------+----------+
```

   SSM Mode:

```
   |   8    | 4 | 4 |    16     | 4 |       60        |   32     |
   +--------+----+----+-----------+----+-----------------+----------+
   |11111111|0011|scop|00.......00|64IX|  sub-group-id  |v4 address|
   +--------+----+----+-----------+----+-----------------+----------+
   |                                                    |          |
   v                                                    v          v
   +----------------------------------------------------+----------+
   |                SSM_MPREFIX64                       |v4 address|
   +----------------------------------------------------+----------+
```
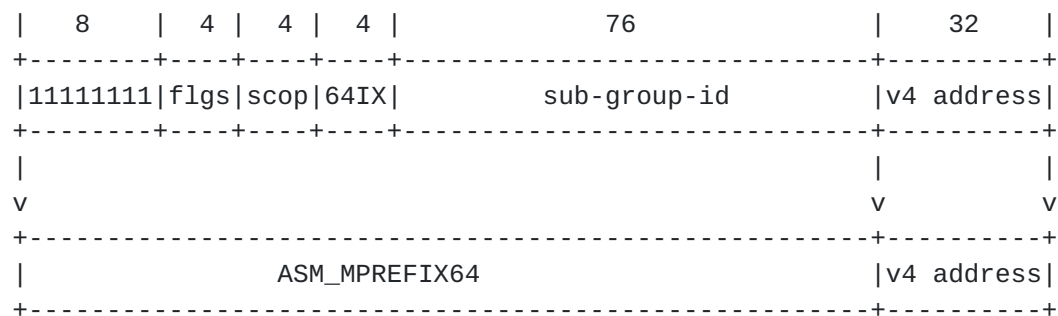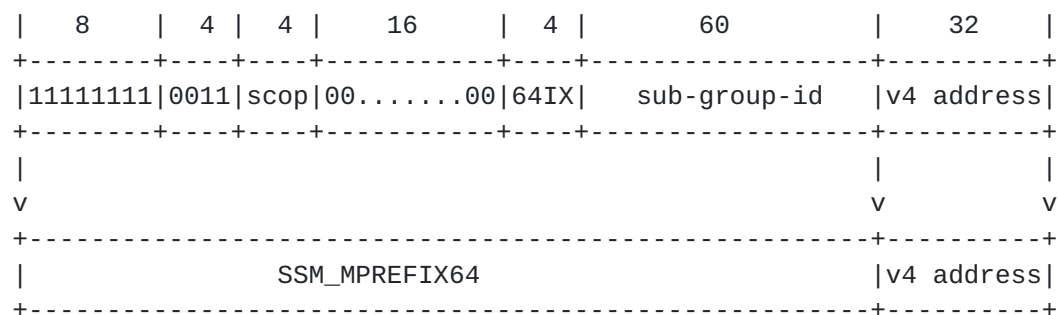
                         Figure 3: MPREFIX64

7. Source IPv4 Address in the IPv6 Realm

   An IPv4 source is represented in the IPv6 realm with its IPv4-
   converted IPv6 address [RFC6052].

8. Address Translation Algorithm

   IPv4-embedded IPv6 multicast addresses are composed according to the
   following algorithm:
   o Concatenate the MPREFIX64 and the 32 bits of the IPv4 address to
      obtain a 128-bit address.

   The IPv4 multicast addresses are extracted from the IPv4-embedded
   IPv6 multicast addresses according to the following algorithm:
   o If the multicast address belongs to ff3x:0:8000/33 or ffxx:
      8000/17, extract the last 32 bits of the IPv6 multicast address.

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9. Examples

   Figure 4 provides an example of ASM IPv4-Embedded IPv6 Address while
   Figure 5 provides an example of SSM IPv4-Embedded IPv6 Address.

```
   +---------------------+-------------+---------------------------+
   |      MPREFIX64      | IPv4 address | IPv4-embedded IPv6 address |
   +---------------------+-------------+---------------------------+
   | ffxx:8000:abc::/96  |  224.1.2.3   |  ffxx:8000:abc::224.1.2.3  |
   +---------------------+-------------+---------------------------+
```

           Figure 4: Example of ASM IPv4-embedded IPv6 address

```
   +---------------------+-------------+---------------------------+
   |      MPREFIX64      | IPv4 address | IPv4-embedded IPv6 address |
   +---------------------+-------------+---------------------------+
   |   ff3x:0:8000::/96   |  232.1.2.3   |   ff3x:0:8000::232.1.2.3   |
   +---------------------+-------------+---------------------------+
```

           Figure 5: Example of SSM IPv4-embedded IPv6 address

10. IANA Considerations

   Authors of this document request to reserve:
   o ff3x:0:8000/33 SSM block to embed an IPv4 multicast address in the
      last 32 bits.
   o ffxx:8000/17 ASM block to embed an IPv4 multicast address in the
      last 32 bits.

11. Security Considerations

   This document defines an address format to embed an IPv4 multicast
   address in an IPv6 multicast address. The same security
   considerations as those discussed in [RFC6052] are to be taken into
   consideration.

12. Acknowledgements

   Many thanks to R. Bonica, B. Sarikaya, P. Savola, T. Tsou and C.
   Bormann for their comments and review.

13. References

13.1. Normative References

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13.2. Informative References

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          Description Protocol", RFC 4566, July 2006.

Appendix A. Design Choices

A.1. Why an Address Format is Needed for Multicast IPv4-IPv6 Interconnection?

Arguments why an IPv6 address format is needed to embed multicast
IPv4 address are quite similar to those of [RFC6052]. Concretely,
the definition of a multicast address format embedding a multicast
IPv4 address allows:

o Stateless IPv4-IPv6 header translation of multicast flows;
o Stateless IPv4-IPv6 PIM interworking function;
o Stateless IGMP-MLD interworking function (e.g., required for an
   IPv4 receiver to access to IPv4 multicast content via an IPv6
   network);
o Stateless (local) synthesis of IPv6 address when IPv4 multicast
   address are embedded in application payload (e.g., SDP [RFC4566]);
o Except the provisioning of the same MPREFIX64, no coordination is
   required between IPv4-IPv6 PIM interworking function, IGMP-MLD
   interworking function, IPv4-IPv6 Interconnection Function and any
   ALG (Application Level Gateway) in the path;
o Minimal operational constraints on the multicast address
   management: IPv6 multicast addresses can be constructed using what
   has been deployed for IPv4 delivery mode.

A.2. Why Identifying an IPv4-Embedded IPv6 Multicast Address is Required?

Reserving an M-bit in the IPv6 multicast address (which is equivalent
to reserving a dedicated multicast block for IPv4-IPv6
interconnection purposes) is a means to guide the address selection
process at the receiver side; in particular it assists the receiver
to select the appropriate IP multicast address while avoiding to
involve an IPv4-IPv6 interconnection function in the path.

Two use cases to illustrate this behavior are provided below:

1. An ALG is required to help an IPv6 receiver to select the
    appropriate IP address when only the IPv4 address is advertised
    (e.g., using SDP); otherwise the access to the IPv4 multicast
    content can not be offered to the IPv6 receiver. The ALG may be
    located downstream the receiver. As such, the ALG does not know
    in advance whether the receiver is dual-stack or IPv6-only. The
    ALG may be tuned to insert both the original IPv4 address and
    corresponding IPv6 multicast address. If the M-bit is not used,
    a dual-stack receiver may prefer to use the IPv6 address to
    receive the multicast content. This address selection would
    require multicast flows to cross an IPv4-IPv6 interconnection
    function.
2. In order to avoid involving an ALG in the path, an IPv4-only
    source can advertise both its IPv4 address and IPv4-embedded IPv6
    multicast address. If the M-bit is not used, a dual-stack
    receiver may prefer to use the IPv6 address to receive the
    multicast content. This address selection would require
    multicast flows to cross an IPv4-IPv6 interconnection function.

Reserving an M-bit in the IPv6 multicast address for IPv4-IPv6
interconnection purposes mitigates the issues discussed in
[I-D.ietf-behave-nat64-learn-analysis] in a multicast context.

A.3. Location of the IPv4 Address

There is no strong argument to allow for flexible options to encode
the IPv4 address inside the multicast IPv6 address. The option
retained by the authors is to encode the multicast IPv4 address in
the low-order 32 bits of the IPv6 address.

This choice is also motivated by the need to be compliant with
[RFC3306] and [RFC3956].

A.4. Location of the M-bit

Figure 6 is a reminder of the IPv6 multicast address format as
defined in [RFC4291]:

```
      |   8    | 4 | 4 |                 112 bits                   |
      +------- -+----+----+---------------------------------------------+
      |11111111|flgs|scop|              group ID                       |
      +--------+----+----+---------------------------------------------+
                                    +-+-+-+-+
         flgs is a set of 4 flags:   |0|R|P|T|
                                    +-+-+-+-+
   *  "T-bit" is defined in [RFC4291];
   *  "P-bit" is defined in [RFC3306]
   *  "R-bit" is defined in [RFC3956]
```

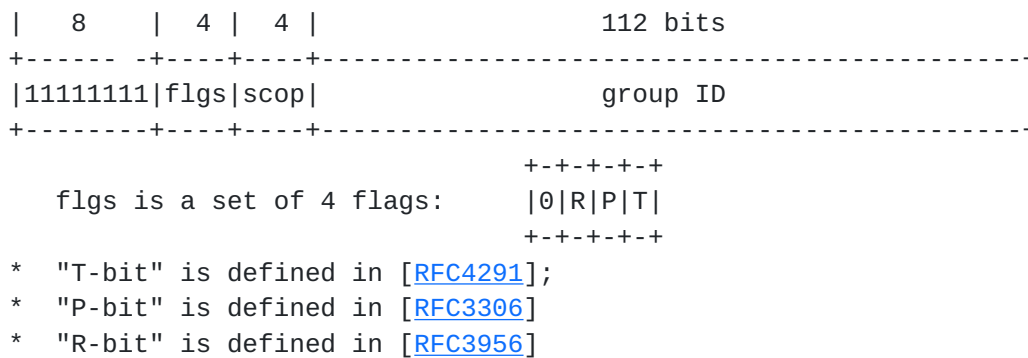   Figure 6: IPv6 Multicast address format as defined in RFC4291

   It was tempting to use the remaining flag to indicate whether an IPv6
   address embeds an IPv4 address or not. This choice has been
   abandoned by the authors for various reasons:
   o ff3x::/32 is defined as SSM. Defining a new flag would require
      standards and implementations to also treat ffbx::/32 as SSM.
   o Prefixes starting with ff7x are defined as embedded-RP, but not
      prefixes starting with fffx. Below is provided an excerpt from
      [RFC3956]:
         " ...the encoding and the protocol mode used when the two high-
         order bits in "flgs" are set to 11 ("fff0::/12") is
         intentionally unspecified until such time that the highest-
         order bit is defined. Without further IETF specification,
         implementations SHOULD NOT treat the fff0::/12 range as
         Embedded-RP."
         as such defining a new flag would require implementations to
         also treat ff7x::/12 as embedded-RP prefix.
   o This is the last remaining flag and at this stage we are not sure
      whether there is other usage scenarios of the flag.

   As a conclusion, the remaining flag is not used to indicate an IPv6
   multicast address embeds an IPv4 multicast address. However the
   following constraints should be met:

      (1) Belong to ff3x::/32 and be compatible with unicast-based
      prefix [RFC3306] for SSM. Note that [RFC3306] suggests to set
      "plen" to 0 and "network-prefix" to 0.
      (2) Be compatible with embedded-RP [RFC3956] and unicast-based
      prefix [RFC3306] for ASM;
      (3) Avoid ff3x::4000:0001-ff3x::7fff:ffff which is reserved for
      IANA.
   Meeting (1) and (2) with the same location of the M-bit is not
   feasible without modifying embedded-RP and unicast-based prefix
   specifications; this option is avoided.

   As a consequence, two multicast blocks are proposed to be used when

embedding IPv4 address: one block for ASM (Section 3) and another
one for the SSM (Section 4).

A.5. Encapsulation vs. Translation

IPv4-IPv6 encapsulator and translator may be embedded in the same
device or even implemented with the same software module. In order
to help the function whether an encapsulated IPv6 multicast packets
or translated IPv6 ones are to be transferred. It was tempting to
define an S-bit for that purpose but this choice has been abandoned
in favor of the recommendation to use distinct MPREFIX64 for each
scheme.

As such, there is no need to reserve a bit in the IPv6 multicast
address to separate between the translation and the encapsulation
schemes.

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