           Overview of the Internet Multicast Addressing Architecture

Abstract

   The lack of up-to-date documentation on IP multicast address
   allocation and assignment procedures has caused a great deal of
   confusion. To clarify the situation, this memo describes the
   allocation and assignment techniques and mechanisms currently (as of
   this writing) in use.

Status of This Memo

   This document is not an Internet Standards Track specification; it is
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1. Introduction

   Good, up-to-date documentation of IP multicast is close to
   non-existent. Particularly, this is an issue with multicast address
   allocations (to networks and sites) and assignments (to hosts and
   applications). This problem is stressed by the fact that there
   exists confusing or misleading documentation on the subject
   [RFC2908]. The consequence is that those who wish to learn about IP
   multicast and how the addressing works do not get a clear view of the
   current situation.

   The aim of this document is to provide a brief overview of multicast
   addressing and allocation techniques. The term "addressing
   architecture" refers to the set of addressing mechanisms and methods
   in an informal manner.

It is important to note that Source-Specific Multicast (SSM)
[RFC4607] does not have these addressing problems because SSM group
addresses have only local significance; hence, this document focuses
on the Any Source Multicast (ASM) model.

This memo obsoletes and re-classifies RFC 2908 to Historic, and
re-classifies RFCs 2776 and 2909 to Historic.

1.1. Terminology: Allocation or Assignment

Almost all multicast documents and many other RFCs (such as DHCPv4
[RFC2131] and DHCPv6 [RFC3315]) have used the terms "address
allocation" and "address assignment" interchangeably. However, the
operator and address management communities use these terms for two
conceptually different processes.

In unicast operations, address allocations refer to leasing a large
block of addresses from the Internet Assigned Numbers Authority
(IANA) to a Regional Internet Registry (RIR), or from an RIR to a
Local Internet Registry (LIR), possibly through a National Internet
Registry (NIR). Address assignments, on the other hand, are the
leases of smaller address blocks or even single addresses to the end-
user sites or end-users themselves.

Therefore, in this memo, we will separate the two different
functions: "allocation" describes how larger blocks of addresses are
obtained by the network operators, and "assignment" describes how
applications, nodes, or sets of nodes obtain a multicast address for
their use.

2. Multicast Address Allocation

Multicast address allocation, i.e., how a network operator might be
able to obtain a larger block of addresses, can be handled in a
number of ways, as described below.

Note that these are all only pertinent to ASM -- SSM requires no
address block allocation because the group address has only local
significance (however, we discuss the address assignment inside the
node in Section 3.2).

2.1. Derived Allocation

Derived allocations take the unicast prefix or some other properties
of the network (e.g., an autonomous system (AS) number) to determine
unique multicast address allocations.

2.1.1. GLOP Allocation

   GLOP address allocation [RFC3180] inserts the 16-bit public AS number
   in the middle of the IPv4 multicast prefix 233.0.0.0/8, so that each
   AS number can get a /24 worth of multicast addresses. While this is
   sufficient for multicast testing or small-scale use, it might not be
   sufficient in all cases for extensive multicast use.

   A minor operational debugging issue with GLOP addresses is that the
   connection between the AS and the prefix is not apparent from the
   prefix when the AS number is greater than 255, but has to be
   calculated (e.g., as described in [RFC3180], AS 5662 maps to
   233.22.30.0/24). A usage issue is that GLOP addresses are not tied
   to any prefix but to routing domains, so they cannot be used or
   calculated automatically.

   GLOP mapping is not available with 4-byte AS numbers [RFC4893].
   Unicast-prefix-based allocation or an IANA allocation from "AD-HOC
   Block III" (the previous so-called "EGLOP" (Extended GLOP) block)
   could be used instead, as needed.

   The GLOP allocation algorithm has not been defined for IPv6 multicast
   because the unicast-prefix-based allocation (described below)
   addresses the same need in a simpler fashion.

2.1.2. Unicast-Prefix-Based Allocation

   RFC 3306 [RFC3306] describes a mechanism that embeds up to 64 high-
   order bits of an IPv6 unicast address in the prefix part of the IPv6
   multicast address, leaving at least 32 bits of group-id space
   available after the prefix mapping.

   A similar IPv4 mapping is described in [RFC6034], but it provides a
   limited number of addresses (e.g., 1 per IPv4 /24 block).

   The IPv6 unicast-prefix-based allocations are an extremely useful way
   to allow each network operator, even each subnet, to obtain multicast
   addresses easily, through an easy computation. Further, as the IPv6
   multicast header also includes the scope value [RFC4291], multicast
   groups of smaller scope can also be used with the same mapping.

   The IPv6 Embedded Rendezvous Point (RP) technique [RFC3956], used
   with Protocol Independent Multicast - Sparse Mode (PIM-SM), further
   leverages the unicast-prefix-based allocations, by embedding the
   unicast prefix and interface identifier of the PIM-SM RP in the
   prefix. This provides all the necessary information needed to the
   routing systems to run the group in either inter- or intra-domain
   operation. A difference from RFC 3306 is, however, that the hosts

   cannot calculate their "multicast prefix" automatically (as the
   prefix depends on the decisions of the operator setting up the RP),
   but instead require an assignment method.

   All the IPv6 unicast-prefix-based allocation techniques provide a
   sufficient amount of multicast address space for network operators.

2.2. Administratively Scoped Allocation

   Administratively scoped multicast address allocation [RFC2365] is
   provided by two different means: under 239.0.0.0/8 in IPv4 or by
   4-bit encoding in the IPv6 multicast address prefix [RFC4291].

   Since IPv6 administratively scoped allocations can be handled with
   unicast-prefix-based multicast addressing as described in
   Section 2.1.2, we'll only discuss IPv4 in this section.

   The IPv4 administratively scoped prefix 239.0.0.0/8 is further
   divided into Local Scope (239.255.0.0/16) and Organization Local
   Scope (239.192.0.0/14); other parts of the administrative scopes are
   either reserved for expansion or undefined [RFC2365]. However,
   RFC 2365 is ambiguous as to whether the enterprises or the IETF are
   allowed to expand the space.

   Topologies that act under a single administration can easily use the
   scoped multicast addresses for their internal groups. Groups that
   need to be shared between multiple routing domains (even if not
   propagated through the Internet) are more problematic and typically
   need an assignment of a global multicast address because their scope
   is undefined.

   There are a large number of multicast applications (such as "Norton
   Ghost") that are restricted either to a link or a site, and it is
   extremely undesirable to propagate them further (beyond the link or
   the site). Typically, many such applications have been given or have
   hijacked a static IANA address assignment. Given the fact that
   assignments to typically locally used applications come from the same
   range as global applications, implementing proper propagation
   limiting is challenging. Filtering would be easier if a separate,
   identifiable range would be used for such assignments in the future;
   this is an area of further future work.

   There has also been work on a protocol to automatically discover
   multicast scope zones [RFC2776], but it has never been widely
   implemented or deployed.

2.3. Static IANA Allocation

   In some rare cases, organizations may have been able to obtain static
   multicast address allocations (of up to 256 addresses) directly from
   IANA. Typically, these have been meant as a block of static
   assignments to multicast applications, as described in Section 3.4.1.
   If another means of obtaining addresses is available, that approach
   is preferable.

   Especially for those operators that only have a 32-bit AS number and
   need IPv4 addresses, an IANA allocation from "AD-HOC Block III" (the
   previous so-called "EGLOP" block) is an option [RFC5771].

2.4. Dynamic Allocation

   RFC 2908 [RFC2908] proposed three different layers of multicast
   address allocation and assignment, where layer 3 (inter-domain
   allocation) and layer 2 (intra-domain allocation) could be applicable
   here. The Multicast Address-Set Claim Protocol (MASC) [RFC2909] is
   an example of the former, and the Multicast Address Allocation
   Protocol (AAP) [MALLOC-AAP] (abandoned in 2000 due to lack of
   interest and technical problems) is an example of the latter.

   Both of the proposed allocation protocols were quite complex, and
   have never been deployed or seriously implemented.

   It can be concluded that dynamic multicast address allocation
   protocols provide no benefit beyond GLOP/unicast-prefix-based
   mechanisms and have been abandoned.

3. Multicast Address Assignment

   There are a number of possible ways for an application, node, or set
   of nodes to learn a multicast address, as described below.

   Any IPv6 address assignment method should be aware of the guidelines
   for the assignment of group-IDs for IPv6 multicast addresses
   [RFC3307].

3.1. Derived Assignment

   There are significantly fewer options for derived address assignment
   compared to derived allocation. Derived multicast assignment has
   only been specified for IPv6 link-scoped multicast [RFC4489], where
   the EUI64 is embedded in the multicast address, providing a node with
   unique multicast addresses for link-local ASM communications.

3.2. SSM Assignment inside the Node

   While SSM multicast addresses have only local (to the node)
   significance, there is still a minor issue on how to assign the
   addresses between the applications running on the same IP address.

   This assignment is not considered to be a problem, because typically
   the addresses for these applications are selected manually or
   statically, but if done using an Application Programming Interface
   (API), the API could check that the addresses do not conflict prior
   to assigning one.

3.3. Manually Configured Assignment

   With manually configured assignment, a network operator who has a
   multicast address prefix assigns the multicast group addresses to the
   requesting nodes using a manual process.

   Typically, the user or administrator that wants to use a multicast
   address for a particular application requests an address from the
   network operator using phone, email, or similar means, and the
   network operator provides the user with a multicast address. Then
   the user/administrator of the node or application manually configures
   the application to use the assigned multicast address.

   This is a relatively simple process; it has been sufficient for
   certain applications that require manual configuration in any case,
   or that cannot or do not want to justify a static IANA assignment.
   The manual assignment works when the number of participants in a
   group is small, as each participant has to be manually configured.

   This is the most commonly used technique when the multicast
   application does not have a static IANA assignment.

3.4. Static IANA Assignment

   In contrast to manually configured assignment, as described above,
   static IANA assignment refers to getting an assignment for the
   particular application directly from IANA. There are two main forms
   of IANA assignment: global and scope-relative. Guidelines for IANA
   are described in [RFC5771].

3.4.1. Global IANA Assignment

   Globally unique address assignment is seen as lucrative because it's
   the simplest approach for application developers, since they can then
   hard-code the multicast address. Hard-coding requires no lease of
   the usable multicast address, and likewise the client applications do

   not need to perform any kind of service discovery (but depend on
   hard-coded addresses). However, there is an architectural scaling
   problem with this approach, as it encourages a "land-grab" of the
   limited multicast address space.

3.4.2. Scope-Relative IANA Assignment

   IANA also assigns numbers as an integer offset from the highest
   address in each IPv4 administrative scope, as described in [RFC2365].
   For example, the SLPv2 discovery scope-relative offset is "2", so the
   SLPv2 discovery address within IPv4 Local-Scope (239.255.0.0/16) is
   "239.255.255.253"; within the IPv4 Organization Local-Scope
   (239.192.0.0/14), it is "239.195.255.253"; and so on.

   Similar scope-relative assignments also exist with IPv6 [RFC2375].
   As IPv6 multicast addresses have much more flexible scoping, scope-
   relative assignments are also applicable to global scopes. The
   assignment policies are described in [RFC3307].

3.5. Dynamic Assignments

   Layer 1 as defined in RFC 2908 [RFC2908] described dynamic assignment
   from Multicast Address Allocation Servers (MAAS) to applications and
   nodes, with the Multicast Address Dynamic Client Allocation Protocol
   (MADCAP) [RFC2730] as an example. Since then, other mechanisms have
   also been proposed (e.g., DHCPv6 assignment
   [MCAST-DHCPv6]), but these have not gained traction.

   It would be rather straightforward to deploy a dynamic assignment
   protocol that would lease group addresses based on a multicast prefix
   to applications wishing to use multicast. However, only few have
   implemented MADCAP (i.e., it is not significantly deployed). It is
   not clear if the sparse deployment is due to a lack of need for the
   protocol. Moreover, it is not clear how widely, for example, the
   APIs for communication between the multicast application and the
   MADCAP client operating at the host have been implemented [RFC2771].

   An entirely different approach is the Session Announcement Protocol
   (SAP) [RFC2974]. In addition to advertising global multicast
   sessions, the protocol also has associated ranges of addresses for
   both IPv4 and IPv6 that can be used by SAP-aware applications to
   create new groups and new group addresses. Creating a session (and
   obtaining an address) is a rather tedious process, which is why it
   isn't done all that often. It is also worth noting that the IPv6 SAP
   address is unroutable in the inter-domain multicast.

Conclusions about dynamic assignment protocols are that:

1. multicast is not significantly attractive in the first place,

2. most applications have a static IANA assignment and thus require
    no dynamic or manual assignment,

3. those applications that cannot be easily satisfied with IANA or
    manual assignment (i.e., where dynamic assignment would be
    desirable) are rather marginal, or

4. there are other reasons why dynamic assignments are not seen as a
    useful approach (for example, issues related to service
    discovery/rendezvous).

In consequence, more work on rendezvous/service discovery would be
needed to make dynamic assignments more useful.

4. Summary and Future Directions

This section summarizes the mechanisms and analysis discussed in this
memo, and presents some potential future directions.

4.1. Prefix Allocation

A summary of prefix allocation methods for ASM is shown in Figure 1.

```
+-------+-------------------------------+--------+--------+
| Sect. | Prefix allocation method      | IPv4   | IPv6   |
+-------+-------------------------------+--------+--------+
| 2.1.1 | Derived: GLOP                 | Yes    | NoNeed*|
| 2.1.2 | Derived: Unicast-prefix-based | No     | Yes    |
|  2.2  | Administratively scoped       | Yes    | NoNeed*|
|  2.3  | Static IANA allocation        | Yes**  | No     |
|  2.4  | Dynamic allocation protocols  | No     | No     |
+-------+-------------------------------+--------+--------+
 *   = the need satisfied by IPv6 unicast-prefix-based allocation
 ** = mainly using the AD-HOC block III (formerly called "EGLOP")
```

                          Figure 1

   o Only ASM is affected by the assignment/allocation issues.

   o With IPv4, GLOP allocations provide a sufficient IPv4 multicast
      allocation mechanism for those that have a 16-bit AS number. IPv4
      unicast-prefix-based allocation offers some addresses. IANA is
      also allocating from the AD-HOC block III (formerly called
      "EGLOP"), especially with 32-bit AS number holders in mind.
      Administratively scoped allocations provide the opportunity for
      internal IPv4 allocations.

   o With IPv6, unicast-prefix-based addresses and the derivatives
      provide a good allocation strategy, and this also works for scoped
      multicast addresses.

   o Dynamic allocations are too complex and unnecessary a mechanism.

4.2. Address Assignment

   A summary of address assignment methods is shown in Figure 2.

```
     +--------+------------------------------+----------+----------+
     | Sect.  | Address assignment method    | IPv4     | IPv6     |
     +--------+------------------------------+----------+----------+
     |  3.1   | Derived: link-scope addresses|   No     |   Yes    |
     |  3.2   | SSM (inside the node)        |  Yes     |   Yes    |
     |  3.3   | Manual assignment            |  Yes     |   Yes    |
     |  3.4.1 | Global IANA/RIR assignment   |LastResort|LastResort|
     |  3.4.2 | Scope-relative IANA assignment|  Yes    |   Yes    |
     |  3.5   | Dynamic assignment protocols |  Yes     |   Yes    |
     +--------+------------------------------+----------+----------+
```

                                Figure 2

   o Manually configured assignment is typical today, and works to a
      sufficient degree in smaller scale.

   o Global IANA assignment has been done extensively in the past.
      Scope-relative IANA assignment is acceptable, but the size of the
      pool is not very high. Inter-domain routing of IPv6 IANA-assigned
      prefixes is likely going to be challenging, and as a result that
      approach is not very appealing.

   o Dynamic assignment, e.g., MADCAP, has been implemented, but there
      is no wide deployment. Therefore, either there are other gaps in
      the multicast architecture, or there is no sufficient demand for
      it in the first place when manual and static IANA assignments are
      available. Assignments using SAP also exist but are not common;
      global SAP assignment is infeasible with IPv6.

      o Derived assignments are only applicable in a fringe case of link-
         scoped multicast.

4.3. Future Actions

      o Multicast address discovery/"rendezvous" needs to be analyzed at
         more length, and an adequate solution provided. See
         [ADDRDISC-PROB] and [MSA-REQ] for more information.

      o The IETF should consider whether to specify more ranges of the
         IPv4 administratively scoped address space for static allocation
         for applications that should not be routed over the Internet (such
         as backup software, etc. -- so that these wouldn't need to use
         global addresses, which should never leak in any case).

      o The IETF should consider its static IANA allocations policy, e.g.,
         "locking it down" to a stricter policy (like "IETF Consensus") and
         looking at developing the discovery/rendezvous functions, if
         necessary.

5. Acknowledgements

   Tutoring a couple of multicast-related papers, the latest by Kaarle
   Ritvanen [RITVANEN], convinced the author that updated multicast
   address assignment/allocation documentation is needed.

   Multicast address allocations/assignments were discussed at the
   MBONED WG session at IETF 59 [MBONED-IETF59].

   Dave Thaler, James Lingard, and Beau Williamson provided useful
   feedback for the preliminary version of this memo. Myung-Ki Shin,
   Jerome Durand, John Kristoff, Dave Price, Spencer Dawkins, and Alfred
   Hoenes also suggested improvements.

6. IANA Considerations

   IANA considerations in Sections 4.1.1 and 4.1.2 of obsoleted and now
   Historic [RFC2908] were never implemented in the IANA registry.

7. Security Considerations

   This memo only describes different approaches to allocating and
   assigning multicast addresses, and this has no security
   considerations; the security analysis of the mentioned protocols is
   out of scope of this memo.

   Obviously, the dynamic assignment protocols in particular are
   inherently vulnerable to resource exhaustion attacks, as discussed,
   e.g., in [RFC2730].

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