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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.

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Table of Contents

1. Introduction	2
1.1. Terminology: Allocation or Assignment	3
2. Multicast Address Allocation	3
2.1. Derived Allocation	3
2.1.1. GLOP Allocation	4
2.1.2. Unicast-Prefix-Based Allocation	4
2.2. Administratively Scoped Allocation	5
2.3. Static IANA Allocation	6
2.4. Dynamic Allocation	6
3. Multicast Address Assignment	6
3.1. Derived Assignment	6
3.2. SSM Assignment inside the Node	7
3.3. Manually Configured Assignment	7
3.4. Static IANA Assignment	7
3.4.1. Global IANA Assignment	7
3.4.2. Scope-Relative IANA Assignment	8
3.5. Dynamic Assignments	8
4. Summary and Future Directions	9
4.1. Prefix Allocation	9
4.2. Address Assignment	10
4.3. Future Actions	11
5. Acknowledgements	11
6. IANA Considerations	11
7. Security Considerations	11
8. References	12
8.1. Normative References	12
8.2. Informative References	13

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].

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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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