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Overview of the Internet Multicast Addressing Architecture
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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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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 of 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) [I-D.ietf-ssm-arch] does not have these addressing problems; hence, this document focuses on the Any Source Multicast (ASM) model.

This memo obsoletes RFCs 2776, 2908, and 2909 and re-classifies them 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 "assignment" interchangeably. However, the operator and address management communities use these for two conceptually different processes.

In unicast operations, address allocations refer to leasing a large block of addresses from Internet Assigned Numbers Authority (IANA) to a Regional Internet Registry (RIR) or from 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 to determine unique multicast address allocations.

2.1.1. GLOP Allocation

GLOP address allocation [RFC3180] inserts the 16-bit public Autonomous System (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., from [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.

2.1.2. Unicast-prefix -based Allocation

RFC 3306 [RFC3306] describes a mechanism which embeds up to 64 first 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 mapping has been proposed for IPv4 [I-D.ietf-mboned-ipv4-uni-based-mcast], but it provides a rather low amount of addresses (e.g., 1 per an IPv4 /24 block). While there exist large networks without an AS number of their own, this has not been seen to add sufficient value compared to GLOP addressing.

The IPv6 unicast-prefix-based allocations are an extremely useful way to allow each network operator, even each subnet, obtain multicast addresses easily, through an easy computation. Further, as the IPv6

multicast header also includes the scope value [RFC3513], multicast groups of smaller scope can also be used with the same mapping.

The IPv6 Embedded 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 Rendezvous Point (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 to 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 rather requires an assignment method.

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

2.2. Scope-relative Allocation

Administratively scoped multicast [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 [RFC3513].

As IPv6 scope-relative allocations can be handled with unicast-prefix-based multicast addressing as described in Section 2.1.2, and there is no need for separate scope-relative allocations, we'll just discuss IPv4 in this section.

The IPv4 scope-relative prefix 239.0.0.0/8 is further divided to 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 it's the enterprises or the IETF who are allowed to expand the space.

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

There is a large number of multicast applications (such as "Norton Ghost") which are restricted either to a link or a site, and it is extremely undesirable to propagate them further (either to the rest of the site, or beyond the site). Typically many such applications have been given or have hijacked a static IANA address assignment;

this makes it challenging to implement proper propagation limiting -- which could be easier if such applications could have been assigned specific scope-relative addresses instead. 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, some 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. In principle, IANA does not allocate multicast address blocks to the operators but GLOP or Unicast-prefix-based allocations should be used instead.

2.4. Dynamic Allocation

RFC 2908 [RFC2908] proposed three different layers of multicast address allocation and assignment, where layers 3 (inter-domain allocation) and layer 2 (intra-domain allocation) could be applicable here. Multicast Address-Set Claim Protocol (MASC) [RFC2909] is an example of the former, and Multicast Address Allocation Protocol (AAP) [I-D.ietf-malloc-aap] (abandoned in 2000 due 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 there are no dynamic multicast address allocation protocols, and other methods such as GLOP or unicast-prefix-based addressing should be used instead.

3. Multicast Address Assignment

For multicast address assignment, i.e., how an application learns the address it can use, or a node (or a set of nodes) learns an address it could use for an application, has a number of options as described below.

Any IPv6 address assignment method should be aware of the guidelines for the assignment of the 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 [I-D.ietf-ipv6-link-scoped-mcast], 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 the 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 node (or more precisely, an IP address).

This assignment is not considered to be a problem because typically the addresses for the 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, the 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 which wants to use a multicast address for 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 which require manual configuration in any case, or which 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 a globally unique assignment

for the particular application directly from IANA. Guidelines for IANA are described in [RFC3171][I-D.ietf-mboned-rfc3171bis].

This is seen as lucrative because it's the simplest approach for application developers because 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 depending 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.

[RFC3138] describes how to handle those GLOP assignments (called "eGLOP") which use the private-use AS number space (233.252.0.0/14). It was envisioned that IANA would delegate the responsibility of these to RIRs, which would assign or allocate addresses as best seemed fit. However, this was never carried out as IANA did not make these allocations to RIRs due to procedural reasons.

In summary, there are applications which have obtained a static IANA assignment and while some of which are really needed, some of which probably should not have been granted. Conversely, there are some applications that have not obtained a static IANA assignment, yet should have requested an assignment and been granted one.

3.5. Dynamic Assignments

The layer 1 of RFC 2908 [RFC2908] described dynamic assignment from Multicast Address Allocation Servers (MAAS) to applications and nodes, with Multicast Address Dynamic Client Allocation Protocol (MADCAP) [RFC2730] as an example. Since then, there has been a proposal for DHCPv6 assignment [I-D.jdurand-assign-addr-ipv6-multicast-dhcpv6].

It would be rather straightforward to deploy a dynamic assignment protocol which would lease group addresses based on a multicast prefix to the applications wishing to use multicast. For example, only few have implemented MADCAP, and it's not significantly deployed. 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 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 which 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. (Note that the IPv6 SAP address is unroutable in the inter-domain multicast.)

A conclusion about dynamic assignment protocols is that:

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

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

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

4. that there are other gaps 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

Summary of prefix allocation methods for ASM is in Figure 1.

Sect.	Prefix allocation method	IPv4	IPv6
2.1.1	Derived: GLOP	Yes	NoNeed*
2.1.2	Derived: Unicast-prefix-based	No -yet	Yes
2.2	Separate Scope-relative	Yes	NoNeed*
2.3	Static IANA allocation	No	No
2.4	Dynamic allocation protocols	No	No

* = the need satisfied by IPv6 unicast-prefix-based allocation.

Figure 1

- Only ASM is affected by the assignment/allocation issues (however, both ASM and SSM have roughly the same address discovery issues).

o GLOP allocations seem to provide a sufficient IPv4 multicast allocation mechanism for now, but could be extended in future. Scope-relative allocations provide the opportunity for internal IPv4 allocations.

o Unicast-prefix-based addresses and the derivatives provide good allocation strategy with IPv6, also for scoped multicast addresses.

o Dynamic allocations are a too complex and unnecessary mechanism.

o Static IANA allocations are generally an architecturally unacceptable approach.

4.2. Address Assignment

Summary of address assignment methods is 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	Static IANA/RIR assignment	LastResort	LastResort
3.5	Dynamic assignment protocols	Yes	Yes

Figure 2

o Manually configured assignment is what's typically done today, and works to a sufficient degree in smaller scale.

o Static IANA assignment has been done extensively in the past, but it needs to be tightened down to prevent problems caused by "land-grabbing".

o Dynamic assignment, e.g., MADCAP has been implemented, but there is no wide deployment, so a solution is there. However, 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 unfeasible 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; the result also needs to be written down to be shown to the IANA static assignment requestors. See [I-D.ietf-mboned-addrdisc-problems] for more.

- o IPv6 multicast DAD and/or multicast prefix communication mechanisms should be analyzed (e.g., [I-D.jdurand-ipv6-multicast-ra]): whether there is demand or not, and specify if yes.

- o The IETF should consider whether to specify more ranges of the IPv4 scope-relative address space for static allocation for applications which 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 seriously 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 multicast-related papers, the latest by Kaarle Ritvanen [RITVANEN] convinced the author that the up-to-date multicast address assignment/allocation documentation is necessary.

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

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

6. IANA Considerations

This memo includes no request to IANA, but as the allocation and assignment of multicast addresses are related to IANA functions, it wouldn't hurt if the IANA reviewed this entire memo.

IANA considerations in sections 4.1.1 and 4.1.2 of [RFC2908] still apply to the administratively scoped prefixes.

IANA may be interested in reviewing the accuracy of the statement on

eGLOP address assignments in Section 3.4.

(RFC-editor: please remove this section at publication.)

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

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Appendix A. Changes

(To be removed prior to publication as an RFC.)

A.1. Changes since -01

- o Mention the mechanisms which haven't been so succesful: eGLOP and MZAP.

- o Remove the appendices on multicast address discovery (a separate draft now) and IPv4 unicast-prefix-based multicast addressing.
- o Add a note on scope-relative address space and the expansion ambiguity.
- o Remove the references to draft-ietf-mboned-ipv6-issues-xx.txt
- o Minor editorial cleanups.

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