

## The Evolution of Multicast Review

This paper was published in the IEEE Network Special Issue on Multicasting Magazine. The goals of this special issue were to provide an understanding of the design, performance, and deployment of various multicast technologies, as well as to determine a shared direction of future research and development in multicast. As can be deduced from the title, this paper tries to tackle the first of these two goals by giving a broad understanding of many different multicast technologies and how they came to be.

The idea of multicast had been around for over a decade at the time of this paper. While it wasn't the newest discovery in network computing, many variations of it existed and continued to grow. Clearly it would play a large part in the future of the internet, and thus was an important enough topic to warrant its own special issue magazine. As the author mentions in the first sentence of the paper, it was a hot topic.

The abstract mentions that while multicast is very popular, it continues to have problems that affect its growth and future deployment. It clearly states the goal of the paper: to describe the past, present, and future of multicast.

As previously mentioned, multicast has been around for quite some time, first being mentioned in a Ph.D. Dissertation in 1988, yet is still at an early stage of its evolution. The reason for this is undoubtedly the added level of complexity required by routers to implement such technology, which is a big leap from the long standing uni-cast services.

Stephen Deering is responsible for the 1988 dissertation on multicasting, in which he describes the standard model for IP networks. This model includes a set of explicit requirements which describe how systems should send and receive multicast packets. The model states: multicast has the same style of semantics as IP—sources can transmit multicast packets at any time without registering or scheduling transmission. IP multicast is UDP based. All groups are open, sources must only know a multicast address, and do not require group membership to the group they are sending to. A group has no limit on the number of sources. Groups are dynamic in the way that members can join or leave without registering, synchronizing, or negotiating with a group management entity. This standard IP multicast model only describes the end system specifications, not the requirements for network routing, QoS, security, or address allocation.

Motivated by Deering's work, in 1992 the first worldwide multicast event was carried out by the Multicast Backbone (MBone). This was a virtual multicast network in which workstations ran the mrouterd daemon, a process which received unicast encapsulated multicast packets and forwarded them over to the appropriate outgoing interfaces. Routing decisions were made by the original multicast routing protocol Distance Vector Multicast Routing Protocol (DVMRP). It creates multicast trees using

the technique of broadcast-and-prune. This technique essentially broadcasts to all available routers, and routers with no group members connected will send back a prune packet to the source telling it to no longer transmit to the router. This protocol is designed to work best in situations with dense populations of group members. A disadvantage of this design is that all routers must keep state information for every source in the network.

MBone went on to evolve out of a virtual network and into an integrated part of the internet. Actual routers became able to handle multicast packets, and new routing protocols were added. More specifically, these are MOSPF which is an extension to OSPF, and PIM which came in two flavors, Dense Mode (DM) and Sparse Mode (SM) and are both very similar to DVMRP.

The next evolutionary step for multicast was sparse mode protocols. They offered advantages such as better scalability for routing states, and higher efficiency of traffic flow. They also came with a good deal of drawbacks, but different protocols, especially PIM-SM, found solutions to some if not all of these issues. Due to the growth in users of Mbone, the demand for applications and better support of real-time data grew as well.

Along came interdomain multicast, at the time of this paper such technologies existed and were deployed, but considered to be short term solutions. Due to the lack of scalability and elegance, a long term solution was still needed. The near term solution was an extension of BGP called Multiprotocol Extensions to BGP (MBGP), with two added protocols used to build interconnected trees across domain boundaries. These two protocols are PIM-SM and Multicast Source Discovery Protocol (MSDP). Together these three protocols form the near-term solution—MBGP determines the next hop to a host, PIM-SM connects receivers and sources across domain boundaries building multicast trees, and finally MSDP connects sparse mode domains together (which typically utilized PIM-SM as it was the most heavily deployed sparse mode protocol). MSDP accomplishes this by having representatives in each domain announce to other domains the presence of active sources. The MBGP/PIM-SM/MSDP solution had been deployed with success, and had the advantage of being built on previously existing protocols. The main disadvantage is that it could be vulnerable to scalability problems. With the MBGP/PIM-SM/MSDP model, the overhead of managing dynamic groups could become overwhelming particularly due to the way MSDP handles join latency and bursty sources.

If multicast continues to grow in popularity, the overhead of MSDP will eventually become unmanageable. Until a long term solution is deployed, it is an acceptable near term solution.

There are two categories of long term solution ideas, those that are based on the IP multicast standard, and those that want to change the model and simplify the problem. The first proposed solution is Border Gateway Multicast Protocol (BGMP), and falls under the first category. It's key feature is bidirectional shared trees between domains using a single root. It avoids interdomain dependencies by enforcing a strict address allocation scheme, allowing domains to own specific addresses or ranges of

addresses. Due to the needs of BGMP and demands from ISPs, such an address allocation scheme is being worked on.

Two proposals for address allocation are The Multicast Address-Set Claim (MASC), and GLOP. Both are able to work in conjunction with BGMP. MASC acts as a three level multicast address allocation architecture (MAAA), and has mechanisms that guarantee immediate resolution of address collisions. It would act as a top level address allocation protocol between domains, as another protocol called Address Allocation Protocol (AAP) would allocate addresses within a domain, and finally the Multicast Address Dynamic Client Allocation Protocol (MADCAP) would be implemented by hosts to request addresses from a Multicast Address Allocation Server (MAAS).

The other proposed multicast address allocation solution is GLOP. This solution is much simpler, and statically allocates a “glop” of addresses to each autonomous system (AS). The AS number is encoded into the address. There are some issues with GLOP, such as limited number of addresses available to each AS. A solution to this could be to use IPv6 addressing. The next issue is not having a mechanism for assigning addresses within a domain. This could be solved using a protocol like AAP or MADCAP used by MASC.

Some people believe MBGP/PIM-SM/MSDP and BGMP are simply too complex, and propose fundamental changes to the original IP multicast model. One class of proposals called Root Addressed Multicast Architecture (RAMA) does just that. It assumes most multicast applications are single-sourced, and proposes to make the source the root of the tree, vastly reducing overall complexity. Two primary RAMA-style protocols exist, they are Express Multicast and Simple Multicast.

Express Multicast is a single-source protocol in which the root of the tree is placed at the source. It is designed for subscriber based systems like TV broadcasts, file distribution, and any other single source multimedia application.

Similar to Express Multicast, Simple Multicast has the added flexibility of accepting multiple sources per group. One of the multiple sources is chosen to be the primary source, which acts as the root of the tree.

With interdomain routing now a possibility, the issue arises of what to do with the MBone. The solution is to turn MBone into its own AS called AS10888 while the rest of the internet deploys interdomain multicast. The hope is that sites on the MBone will transition to native multicast by deploying an appropriate interdomain solution.

As for Internet2, the plan is to do it “the right way”, which calls for all multicast deployed to be native and sparse mode. All routers must support MBGP/MSDP, and no tunnels are allowed. So far Internet2 has had reasonable success in deploying multicast.

The abstract is well written, it states the problems with multicast and the goals of the paper. It gave a fairly accurate impression of what the paper has to offer.

The paper starts off with a fairly broad history of multicast, talking about MBone and other historical events. It then takes a sharp turn and delves into the intricate details of various existing and future protocols. This sudden change of pace was a bit shocking to the reader, as the two require different styles of reading.

Coming from outside of the field, the beginning history was a perfect level of depth to understand multicasting. The details of the different protocols was hard to understand and keep up with, even though the author did try to explain as many key terms as possible. Some sections concluded with a short paragraph dedicated to summarizing key points and terms, more of these would have been helpful. One big explanation left out that many non-experts may not know is what exactly a “group” is. This term was used throughout the paper, and a vague definition can be implicitly deduced, but one sentence dedicated to its explanation would have been beneficial.

Seeing as this paper was published in a magazine dedicated to multicasting, it is fair to assume the audience would be mostly comprised of people familiar with the topic. A Magazine filled with articles which all cover the very same basics would be quite repetitive and unattractive. So its level of explanation is forgivable.

While this paper doesn't bring anything new to the table, it is a good summary of the past present and current work for the future. It is a perfect fit for a magazine dedicated to the topic of multicast.

The conclusion is simply a short repetition of the goals expressed in both the abstract and introduction, only in the past tense. Given the topic and style of the paper it is understandable for it to be short, but a little more would have left the reader more satisfied.