Global Address Allocation for Wide Area IP-Multicasting

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INTRODUCTION

The *IP-multicast* transmission is the IP level answer for the growing one-to-many content spreading needs in multimedia applications (Hosszú, 2005). Nevertheless the address allocation and service discovery is a problematic field of this technology. Despite of the efficiency of the IP-multicast it has not been deployed in the whole Internet. Especially the global address allocation is a problematic part of the Internet-wide multicasting. This article addresses such problems in order to review the existing methods and the emerging research results.

The IP-multicasting uses a shared IPv4 address range. In Internet-wide applications the dynamic allocation and reuse of the addresses is essential. Recent Internet-wide IP-multicasting protocols (MBGP/MSDP/PIM-SM) have a scalability or complexity problem. The article introduces the existing solution for the wide-area multicasting and also proposes a novel method, which overcomes the limitations of the previous approaches.

BACKGROUND

The IP-multicasting provides an excellent solution for the one-to-many communication problems. The *IP-multicast* is based on the routers, which act as nodes of the multicast distribution tree. In such a way the routers multiply the multicast packets to be forwarded to every member of the multicast group. The IP-multicast method relies on network level mechanisms, since the construction of the multicast delivery tree is based on the multicast routing protocols in the routers. In such a way the IP-multicast is a pure network level communication technology, which is a logical extension of the *unicast* (one-to-one) IP-based communication.

The alternative of the IP-multicast is the *application-level multicast* (ALM), where the multiplication points of the multicast distribution tree are the hosts and not the routers as in case of the IP-multicast (Banerjee, Bhattacharjee, & Kommareddy, 2002). The ALM methods are inherently less efficient than the IP-multicast, since the hosts in case of the ALM generate duplicated traffic around the hosts. Another disadvantage of the ALM is the inherent unreliability of its multiplication points, since these are host, which are run by users without any responsibility for the whole communication.

The sophisticated IP-multicast routing protocols, such as the *distance vector multicast routing protocol* (DVMRP) (Thyagarajan & Deering, 1995), the most widely used *protocol independent multicast—sparse mode* (PIM-SM) (Fenner, Handley, Holbrook, & Kouvelas, 2006), and the experimental *bi-directional protocol independent multicast* (BIDIR-PIM) (Handley, Kouvelas, Speakman, & Vicisano, 2005) ensure that building and ending the multicast distribution trees has already been solved inside a routing domain, where all the routers are under the same administration (or a strict hierarchy of the administrators), where there is a homogenous infrastructure for registering the sources and the receivers. Here the uniform configuration of the routers is possible and the current routers automatically can enable the multicast traffic inside the domain, which means in practice the network of an *autonomous system* (AS). The sophisticated multicast routing protocols work efficiently inside a *multicast* *routing domain*; however, the Internet is composed of several Ass, and the wide-area multicasting needs the inter-AS (inter-domain) routing as well. Unluckily, the cooperation of the ASs in transmitting the multicast traffic has not completely solved yet. It has at least three reasons; one is the address allocation problem, but the source discovery and interdomain routing are still unsolved issues. All of them will be discussed in the following text.

The first problem is related to the topology among the ASs, where the IP-multicast traffic can be forwarded. Its reason is that oppositely to the IP-unicast traffic, the destination of the multicast packets is not single and normally cannot be determined based on the destination address. That is why the peering connections among the autonomous systems developed for the unicast transmission are not appropriate for forwarding the multicast traffic. A different interdomain routing is necessary.

The second problem, which arises at the border of the AS is the *address allocation*. The address range of the IP-multicast is huge, since 270 million different IP-multicast addresses exist. However, theoretically the unwanted address collision can arise and intentional, sometimes malicious, common address usage must be taken into account, too. The dynamic allocation and release of the multicast addresses should also be solved, in order to keep the IP-multicast address allocation scalable.

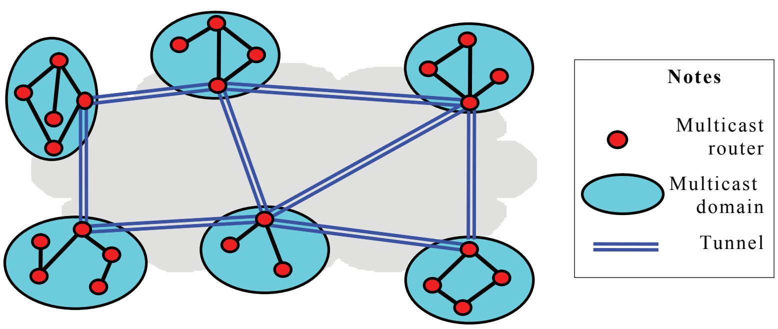
The address allocation is in fact an application level problem. In order to solve it, the *session directory* (SD) networking application is developed for the multicast infrastructure. It can handle the session creation, announcement, and address allocation from multicast applications. The information about the active and scheduled sessions is typically flooded in every 15 minutes (Johnson & Johnson, 1999). However, the Session Directory was appropriate when the IP-multicast was used by researchers, who can trust in the cooperation of every other. The main problem is that SD is not scalable; therefore, it cannot be used Internet-wide. The current Internet needs a more safe and scalable method for the address allocation.

The third problem, called *source discovery*, arises in network level, when in a certain routing domain a multicast address has been allocated, and a new host in another domain should want to join to this multicast group address. The intra-domain multicast routing protocols do not announce the allocated multicast addresses to other domains, so this host has no chance to join the existing multicast session from a remote domain, typically an AS. Since the address allocations and the source discovery are strongly related problems, the possible solutions will be discussed together.

In case of the intra-domain multicast, all of these problems are solved. The multicast addresses are allocated dynamically, and they are registered in router level, for example, in case if the popular PIM-SM multicast routing protocol the *rendezvous point* (RP) router is responsible to register all the used multicast addresses (Kim, Meyer, Kilmer, & Farinacci, 2003).

The problem starts when the multicast islands (where all routers have multicast routing protocols and the *IP-multicast* is available) created in separate routing domains should be connected to each other. The first experiment was the *multicast backbone* (MBONE), which was the first Internet-wide multicast routing and session directory system. It was a logical inter-domain (tunnel) topology over the physical IP level routing, and some commonly used multicast applications (see Figure 1). The used tunneling and routing mechanisms of the DVMRP in the MBONE was one of its weak-

Figure 1. A sample topology of interconnected multicast islands



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