第 XIV 部

IP マルチキャストに関する運用・応用アプリケーション開発

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第1章 Introduction

IP multicast technology is highly advantageous for various applications and future needs in the Internet. The m6bone Working Group in the WIDE Project has been studying for IPv4/IPv6 multicast deployment in the Internet. We published academic papers and provided inputs to the IETF. The following chapters introduce the primary outputs.

第2章 Architecture for IP Multicast Deployment

In this chapter, we firstly describe a realistic IP multicast architecture using the one-to-many multicast communication model called Source-Specific Multicast (SSM). We then explain this communication model and the corresponding routing architecture and examine the statistics obtained for the number of multicast routing entries in our backbone router. We published an academic journal[9], and this chapter pick up some of the points mentioned in this journal.

According to the analysis, we have been working for designing the lightweight IGMPv3 and MLDv2 protocols (LW-IGMPv3 and LW-MLDv2), which simplify the standard (full) versions of IGMPv3 and MLDv2. The interoperability with the full versions and the previous versions of IGMP and MLD is also taken into account. We submitted the corresponding Internet draft to the IETF[131], and this chapter also introduces its contribution.

2.1 Requirement

IP multicast saves processing resources at the data sender and saves network bandwidth because only one copy of each data packet is sent over physical links to an unlimited number of receivers. In addition, it enables data to be transferred more quickly to a large number of receivers than with the repeated unicast model because all copies are delivered in parallel by the network.

The properties of multicast communication are defined as having a *high probability* and a *short delay* in transmitting data to multiple receivers. Therefore, optimizing multicast routes is essential for minimizing delays. Multicast routing protocols used in the Internet must be designed to support wide-area routing — a reasonable optimal path must be established between multicast data senders and receivers. Some essential requirements are *scalability*, *simplicity*, and *independence* of the protocols.

Unfortunately, in addition to the benefits offered by multicast routing protocols, there are more complexities than in unicast routing protocols. In the following subsection, we discuss the Source-Specific Multicast (SSM) architecture, which has recently been recognized as the most feasible multicast communication model for use in the Internet. To understand the situation of IP multicast deployment in the Internet, we investigate experimental data obtained through our operational experience.

2.2 Source-Specific Multicast (SSM)

Multicast communication has run into significant barriers to its wide-scale deployment. Mainly, these barriers are rooted in the problem of building efficient multicast routing trees for dynamic group memberships. Such complexity of multicast routing tree coordination has caused attention to be focused on the traditional many-to-many multicast communication called Any-Source Multicast (ASM).

With regard to widely used multicast applications like live streaming or the contents distribution style applications used in the Internet, the one-to-many or few-to-many communication model, in which the data sender is only one node or a few nodes in a multicast session and the number of the data receivers is many, is usually sufficient. When we consider one-to-many or few-to-many communication, we can assume that multicast data receivers know the address of each data sender, as well as the multicast address, prior to sending the join requests. In this case, each receiver can notify interesting source address(es) with group address to the upstream router on the same LAN as group membership information upon request. This collaborative effort eliminates the source address discovery procedure from multicast routing protocols, which is the key reason of problems caused by traditional multicast routing protocols.

This one-to-many multicast communication model is called Source-Specific Multicast (SSM), because the data receivers specify source and group addresses for their join or leave requests. SSM solely maintains an explicit source-based routing tree; in an SSM communication environment, each receiver site DR only coordinates the appropriate SPTs toward each data sender. An SSM communication model would better facilitate multicast service deployment in the Internet.

2.3 Analysis of Statistical Trend

We analyzed the statistical trends in international multicast backbones using the following measurements to understand the current situation and future needs of IP multicast services.

Figure 2.1 shows the topology of the target networks. The Japanese multicast backbone is known as “JP Multicast IX”, which was previously established for multicast data exchange over MBone. The “Domestic Network” is a network to which the WIDE project and other Japanese research communities are connecting. The “International Backbone” is the connection to Abilene via TransPAC. Our multicast router (MRX — Juniper M20 with JUNOS 5.7) was connected to six multicast routers (MRs) using Gigabit Ethernet interfaces. These routers used PIM-SM, MSDP and MBGP to exchange each routing information required for IPv4 multicast routing. The “Packet Capturing Server” was a PC (Dell PowerEdge 2650 with FreeBSD 5.1) equipped with 2 GB memory and 160 GB hard-disk. It was used to collect routing information

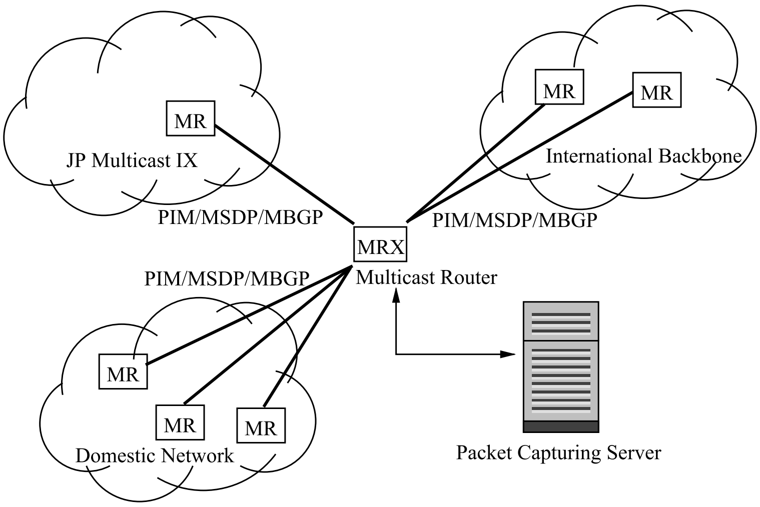

Fig. 2.1. Network and server configuration.

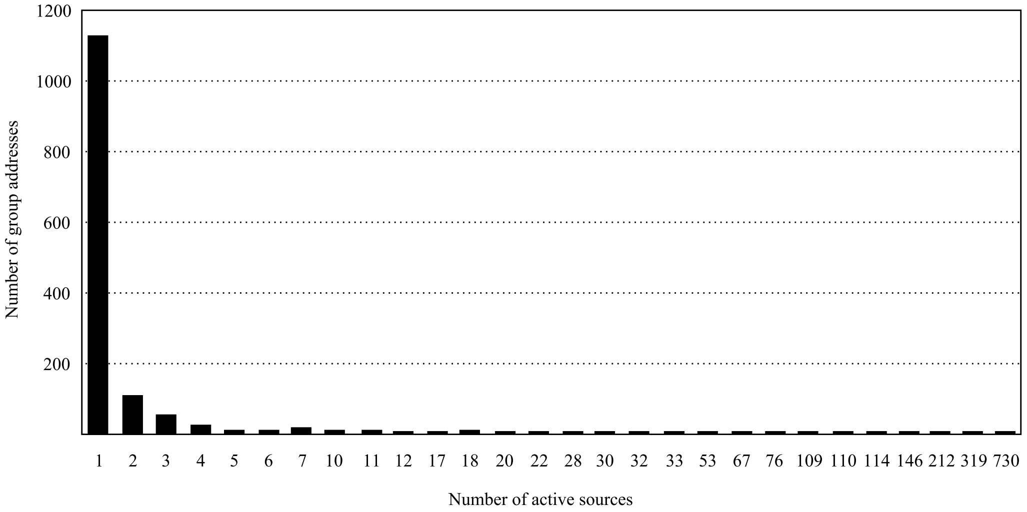

Fig. 2.2. Number of active data sources per multicast session.

from our multicast router MRX. It ran a program that logged into the router to extract the MSDP, MBGP and BGP routing information at eight-hour intervals from Feb. 28 to Mar. 13, 2004.

From the extracted data, the following information is shown distribution of the number of senders per group (Figure 2.2).

Figure 2.2 shows that more than 90% of the multicast sessions were categorized as one-to-many communication, although the network infrastructure supported many-to-many communication. This fact indicates that ASM is not mandatory from the viewpoint of multicast service providers. In other words, SSM does not interfere with the steady deployment of IP multicast, and there should be no problem in replacing ASM with SSM. Although a few multicast sessions were advertised from a large number of senders (e.g. 212, 319, and 730), we believe that they were used for the multicast session announcement by the Session Announcement Protocol (SAP), which requires multicast data senders send announcement messages to the corresponding multicast addresses.

2.4 Lightweight IGMPv3 and MLDv2 Protocols

The multicast protocol architecture works with a common set, including a data sender, a data receiver, and a multicast router. Host-to-router communication is provided by the Internet Group Management Protocol (IGMP) for IPv4 and Multicast Listener Discovery (MLD) for IPv6. When a data receiver wants to join or leave multicast sessions, it notifies the multicast group address by sending an IGMP/MLD join or leave message to the upstream multicast router.

IGMP version 3 (IGMPv3) and MLD version 2 (MLDv2) implement source filtering capability that is not suported by their earlier versions IGMPv2 and MLDv1. An IGMPv3 or MLDv2 capable host can tell which group it would like to join to its upstream router with specifying which sources it does or does not intend to receive multicast traffic from. IGMPv3 and MLDv2 add the capability for a multicast router to also learn which sources are of interest to neighboring systems, for packets sent to any particular multicast address.

The filter-modes are defined for the host and router parts of the protocols respectively to support the source filtering function. If a receiver host wants to receive from specific sources, it sends an IGMPv3 or MLDv2 report with filter-mode set to INCLUDE. If the host does not want to receive from some sources, it sends the report with filter-mode set to EXCLUDE. A source list for the given sources shall be included in the report message.

However, practical applications do not use EXCLUDE mode to block sources so often, because a user or application usually wants to specify desired source addresses, not undesired source addresses to not receive from them. Even if a user wants to explicitly refuse traffic from some sources in a group, when other users in the same shared network have interest in these sources, the corresponding multicast traffic is forwarded to the network after all.

Moreover, supporting both filter-mode has been creating the protocol deployment barrier because of their implementation costs. Our motivation is therefore to propose the simplified IGMPv3 and MLDv2, being named Lightweight IGMPv3 and Lightweight MLDv2 (or LW-IGMPv3 and LW-MLDv2), in which EXCLUDE filter-mode that supports to exclude data come from specified sources is eliminated. Not only LW-IGMPv3 and LW-MLDv2 are compatible with the standard IGMPv3 and MLDv2, but also the protocol operations made by data receiver hosts and routers or switches (performing IGMPv3/MLDv2 snooping) are simplified in the lightweight protocol and complicated operations are hence effectively reduced. Since LW-IGMPv3 and LW-MLDv2 are fully compatible with the full version of these protocols (i.e. the standard IGMPv3 and MLDv2), hosts or routers that have implemented the full version do not need to implement or modify anything to cooperate with LW-IGMPv3/LW-MLDv2 hosts or routers.

第 3 章　Multicast Session Information Distribution

At the second part, we introduce multicast session information announcement scheme including the metadata distribution method.

3.1 A Framework for the Usage of IMGs

One of the possible solution, we contributed to designing Internet Media Guides (IMGs), which provide and deliver structured collections of multimedia descriptions expressed using the Session Description Protocol (SDP), SDPng, or other description formats. They are used to describe sets of multimedia services (e.g., television program schedules, content delivery schedules) and refer to other networked resources including web pages. IMGs provide an envelope for metadata formats and session descriptions defined elsewhere with the aim of facilitating structuring, versioning, referencing, distributing, and maintaining (caching, updating) such information.

IMG metadata may be delivered to a potentially large audience, which uses it to join a subset of the sessions described and which may need to be notified of changes to the IMG metadata. Hence, a framework for distributing IMG metadata in various different ways is needed to accommodate the needs of different audiences: For traditional broadcast-style scenarios, multicast-based (push) distribution of IMG metadata needs to be supported. Where no multicast is available, unicast-based push is required.

The RFC 4435[176] defines a common framework model for IMG delivery mechanisms and their deployment in network entities. There are three fundamental components in the IMG framework model: data types, operation sets, and entities. These components specify a set of framework guidelines for efficient delivery and description of IMG metadata. The data types give generalized means to deliver and manage the consistency of application-specific IMG metadata. IMG operations cover broadcast, multicast distribution, event notification upon change, unicast-based push, and interactive retrievals similar to web pages.

Since we envision that any Internet host can be a sender and receiver of IMG metadata, a host involved in IMG operations performs one or more of the roles defined as the entities in the IMG framework model. The RFC outlines the use of existing protocols to create an IMG delivery infrastructure. It aims to organize existing protocols into a common model and show their capabilities and limitations from the viewpoint of IMG delivery functions.

3.2 An Architecture for the Access of IMG Metadata

IMG metadata may be delivered to a potentially large audience, who use it to join a subset of the sessions described, and who may need to be notified of changes to the IMG metadata. Since content and its structure described by IMG metadata changes as time elapses, an IMG receiver needs to be notified of changes so that IMG metadata and content do not become stale.

The proposed Internet draft[8] defines an architecture for the access of IMG metadata, which satisfies the IMG framework mentioned in RFC 4435.

The IMG framework defines a set of abstract operations for large-scale multicast distribution (“IMG ANNOUNCE”), individual subscription and asynchronous (change) notification (“IMG SUBSCRIBE” and “IMG NOTIFY”), and interactive retrieval (“IMG QUERY” and “IMG RESOLVE”). The proposed Internet draft clarifies the common mechanism that provides the IMG access methods, including the use methods of these corresponding operations and specifications. The typical scenario that an IMG receiver obtains IMG metadata consists of the following three phases: (1) an IMG receiver obtains IMG Uniform Resource Name (URN), (2) an IMG receiver resolves corresponding IMG sender(s), and (3) an IMG receiver starts an IMG transport session to obtain its interesting IMG metadata from the IMG sender.

第 4 章　Conclusion

We have been working for IP multicast deployment and conducted various research towards its further use. While last year we had mainly studied about connectivities among inter- and intra-ASes and had experimental work, we provided concrete and advanced research not only for the infrastructure related topics but also for the higher layer topics including session information announcement and management scheme in this year.

Our future work would improve current research solutions and much relate to the fundamental issues being required in various multimedia streaming services including future Internet TV. In fact, since IMG is too conceptual and may not provide the idea to make concrete implementations, we would further consider the realistic system architecture and actual implementation at the next step. Providing IP multicast stability and robustness should be also convinced in our future work.