Experiments with IPv6 multicast at the Academic and Research Network of Lithuania (LITNET) and link to M6Bone

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Multicast saves processing resources at the sender, network bandwidth and enables data to be transferred more quickly. IPv6 adds a unique and much larger than IP address space, provides security, more efficient routing, support for mobile and an increased number of multicast addresses. This paper describes a set of tests accomplished at the IPv6 production network inside the Information Technology Development Institute (ITDI) of the Kaunas University of Technology (KTU) and the deployment of a test-bed to the purpose to simulate the flow of multicast packets along the backbone from the upstream provider GEANT2. The link of LITNET to the world-wide IPv6 multicast test network M6Bone is eventually reported.

Keywords: IPv6, multicast, streaming, PIM-SM, MLD, LITNET, M6Bone

1. Introduction

Nowadays more and more network applications require the forwarding of the packets from one or more source to a group of receivers. These applications comprise the majority of the data transfer (for instance, the delivery of software upgrades from the developers to the final users), the media streaming (audio, video, text), the data sharing (for instance, a videoconference shared among distributed participants), the data entry (for instance, stock shares), the Web cache refresh and the interactive videogames (for instance, distributed virtual environments or multiplayer games like Quake). A very useful abstraction in behalf of each of these applications is the concept of multicasting [1].

Almost all communications on the Internet today are unicast. At the IP level, each packet sent is forwarded to the destination host identified by the destination IP address in the IP packet header. The IP routers have routing tables specifying where to forward packets based on this destination address. In addition to unicast, there is also multicast. For multicast, the IP destination address refers to a group of IP hosts: the idea is that a packet sent to the multicast group address, should reach all hosts in the group [2].

Internet Protocol version 6 (IPv6) is the new generation of the basic protocol of the Internet. The current version of IP (IP version 4) has several shortcomings which complicate, and in some cases present a barrier to, the further development. The coming IPv6 revolution should remove these barriers and provide a feature-rich environment for the future of global networking [3].

1.1. The M6Bone

The M6Bone is a test network: the aim of this project is to offer an IPv6 multicast service to interested sites all over Europe and beyond (Figure 1). The first goal is to develop an advanced service on IPv6, in order to participate in the promotion of the protocol [4] and through experimentations and experience from operational deployment, to gain an understanding of specific IPv6-related issues for multicast. The main focus of the test-bed is the use of IPv6-enabled versions of traditional multicast tools for conferencing and streaming (e.g. VIC, RAT and VLC), while giving users and administrators at participants sites the opportunity to learn about IPv6 multicast [5].

1.2. LITNET, the National Research and Education Network (NREN) of Lithuania

LITNET is an association of academic research centers and non-profit organizations. The Computer Networking Centre, located at the Information Technology Development Institute (ITDI) of the Kaunas University of Technology (KTU), carries out the management and the development of the network [6]. New technologies like IP telephony, TV multicast, wireless LAN and IPv6 unicast were already introduced in the university campus network and lately modern communication facilities have been installed for the significant upgrade of the backbone capacity.

LITNET participates in the GEANT2 project [7], the pan-European network which connects 34 countries through 30 National Research and Education Networks (NRENs) [8].

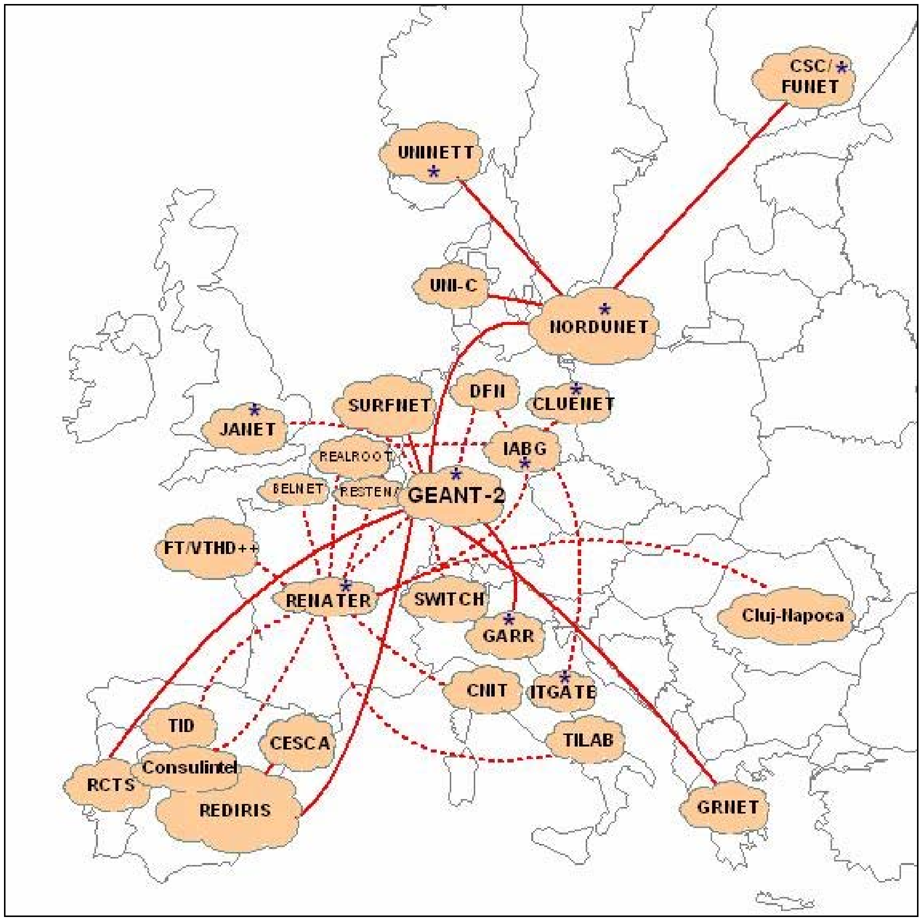

Figure 1. European map of the M6Bone (ISPs)

2. IPv6 Multicast tests at LITNET Network Operating Centre (NOC)

A set of multicast tests has been achieved using the IPv6 production network implemented at the LITNET Network Operating Centre. Two routers have been deployed at the ITDI of the Kaunas University of Technology to manage the IPv6 campus network: the Main Router and the KTU Hostel Router. Linux Debian running on Intel architecture has turned out to be a suitable solution in order to distribute IPv6 packets all along the site. Quagga, a routing software suite for Unix platforms, provides daemons to support OSPFv3 and BGPv4+ [9] and MRD6 implements a modular IPv6 Multicast Routing Framework to supply Multicast Listener Discovery (MLD) and Protocol Independent Multicast-Sparse Mode (PIM-SM) [10]. The two Linux boxes are linked together and to LITNET via a HP Procurve 2626 switch which doesn't provide MLD snooping and causes IPv6 multicast packet flooding. Multicast is particularly useful when transmitting audio and video contents and therefore we have used a effective media player and streaming server like VLC [11] installed on two laptops running Window XP.

The MRD6 configuration file has been modified on both the Linux boxes in order to candidate the Main Router as the RP and to advertise the group mask all along the network via BSR. The source and the receiver have been linked each on one different router and then a set of experiments have been accomplished with the purpose to test the effectiveness of both the MRD6 modules and the VLC client/server capabilities. Permanent/temporary, unicast prefix-based and embedded-RP multicast addresses have been used and both MRD6 and VLC have proved to be stable software supporting the most advanced network features. On the other hand, XP can't manage MLDv2, the new version of MLD, necessary for receivers to join a channel (S,G) and therefore it has been impossible to test PIM-SSM. A different topology has also been set up with both hosts linked to the same router in order to simulate the presence of the source and the receiver on the same LAN.

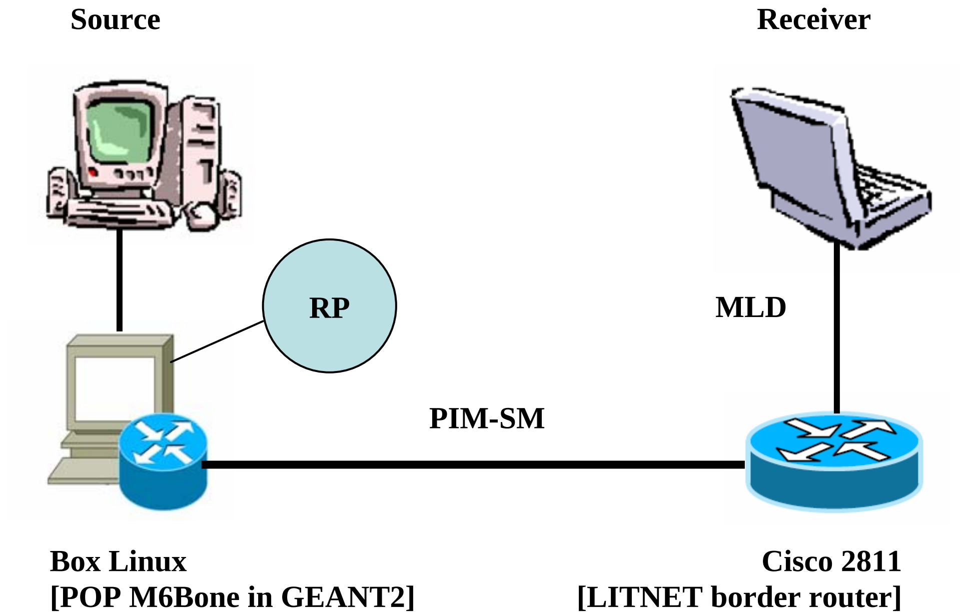

Figure 2. IPv6 Multicast test-bed topology

3. IPv6 Multicast test-bed with box Linux and router Cisco

To the purpose to link the Academic and Research Network of Lithuania to M6Bone, an IPv6 multicast test-bed has been set up at ITDI in order to test the flow of packets from GEANT2 to LITNET border routers (Figure 2).

A box Linux has acted as the M6Bone POP and the Rendezvous Point (RP) while a router Cisco 2811 [12] as the LITNET border equipment. Because PIM is routing-protocol independent, it needs a separate unicast routing table to perform RPF checks. The tables have been created by ordinary unicast routing protocols, OSPFv3 and BGPv4+ in our case, by running Quagga daemons on the box Linux [9] and configuring the IOS on the Cisco 2811 [12][13].

MLD and PIM modules of MRD6 have been loaded on the box Linux in order to offer IPv6 multicast services and the configuration file modified to candidate the router as the RP of the PIM-Domain. Linux doesn't let two applications to share the same port on the same interface, therefore MBGP support could not be implemented as the module would use the port number 179 as BGPv4+.

When IPv6 multicast is set up globally on Cisco IOS, all IPv6 interfaces on the router are automatically enabled also for PIM-SM and MLD [13]. Even if Cisco IOS supports IPv6 multicast address family for Multiprotocol Border Gateway Protocol, MBGP has not been enabled as there was no router to peer with. The RP has been configured statically also on this network device.

Windows XP is one of the most popular platform world-wide and includes an advanced IPv6 implementation intended for development use and trial network deployment. Unfortunately Windows XP does not support MLDv2, so also this time we couldn't test IPv6 SSM. MLDv2 is provided by other OSs, including Linux, and will be supported in Windows Vista and Longhorn server. Netsh is a command-line utility that allows to, either locally or remotely, display or modify the network configuration of a computer that is currently running. The Netsh commands for Interface IPv6 provide a CLI tool that can be used to query and configure IPv6 interfaces, addresses, caches and routes [14].

VLC (initially VideoLAN Client) is a highly portable multimedia player for various audio/video formats and streaming protocols. It can also be used as a server to stream in unicast or multicast in IPv4 or IPv6 on a high-bandwidth network [11].

A UDP/RTP flow of multimedia content from the source to the receiver along the Rendezvous Point Tree (RPT) has been tested out with two sniffer tools like tcpdump and Ethereal as well as MLD-query/report/done, PIM-join/prune and PIM-register/register- stop messages.

4. Link to the world-wide IPv6 Multicast test network (M6Bone)

The last step of our work in ITDI has been to link LITNET to M6Bone.

As IPv6 multicast at the moment is not available in all production networks, in general M6Bone can be considered a tunneled network with edge equipments supporting IPv6 multicast. Non-congruent tunneled topology means different multicast topology to the physical layout for two possible reasons: no support for IPv6 multicast or for IPv6 at all in some parts of the network [13]. The Multicast Routing Information Base (MRIB) makes it possible to have different topologies for unicast and IPv6 multicast, allowing the router to use the multicast routing table for RPF checks and the multicast tree construction. Nowadays static multicast routes and IPv6 multicast address family of MBGP are the only way to populate the MRIB.
M6Bone is a unique PIM-Domain where RENATER is the global RP and can be used by the whole community. Of course, the solution to have a unique global RP does not scale as the M6Bone grows dramatically. A solution is embedded-rp-address. The idea is to embed the address of the RP in the IPv6 multicast address. This is currently deployed in some parts of the M6Bone but this is more and more supported.
The M6Bone users have implemented Linux, BSD and Windows OSs for multicast IPv6 applications. The primary applications have been the classic VIC and RAT for conferencing. VLC has been tested as well for audio and video downstream from the permanent content distributed in M6Bone [4].
GEANT2 is the upstream ISP of LITNET, a M6Bone POP and provides a native IPv6 unicast and multicast connectivity. To the purpose of receiving a media flow from a source inside the PIM-Domain, the address of the global RP in RENATER has been statically configured on the Cisco border router of ITDI. Eventually we have observed a UDP/RTP flow of IPv6 multicast packets from a multimedia source, i.e. UC3M TV Spanish Television, along the RPT towards our VLC running on a Windows XP platform.

5. Conclusions

This paper has described how multicast and IPv6 provide various advantages for meeting current and future Internet needs. The main target has been to link LITNET to M6Bone via GEANT2. Several tests have been accomplished in order to implement IPv6 multicast on the production network of KTU site and at the backbone level.
Nowadays the main routers manufacturers, OSs developers and software houses are wildly supporting IPv6 multicast on their products allowing the new technology to be more and more globally deployed. Yet, it is generally recognized that the multicast routing protocols are fairly complex and require additional maintenance and operational cost to network administrators. Although there has been much research related to IPv6 multicast and most router vendors already support basic multicast routing protocols, there is still a big gap between what is reported as the state-of-the-art in the literature from what is implemented in practice. Other issues pertain to multicast packets broadcasting at the LAN level due to the lack of MLD snooping feature on some network switches and Windows XP incapability to set up a SSM session.
In closing, the future work should focus on the deployment of conferencing sessions via PIM-SSM both inside KTU campus network and with M6Bone connected sites. A further challenge could be to test and implement IPv6 mobile multicast service in ITDI using the production WLAN network.

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