The necessity of multicast for IPTV streaming

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Abstract - The IPTV channels require high bandwidth for high clear television programs. The use of multicast for IPTV service is considered necessary to resolve such problem. IP multicast is a bandwidth-conserving technology that reduces traffic by simultaneously delivering single stream of data to thousand costumers. Applications that take advantage of multicast include IPTV services, distance learning, distribution of software and news. But is it better to apply multicasting in core or in both core and access, this is still a burning question. In this paper we will analyze the most appropriate multicast solution for IPTV streaming. Also we will analyze two versions of IGMP-Internet Group Multicast Protocol (IGMP v1 and IGMP v2) and the communication scenarios between access nodes and service routers.

Key words: - Multicast, Streaming, IPTV, IGMP protocol

1 Introduction

In early IP networks, a packet could be sent to either a single device (unicast) or to all devices (broadcast). A single transmission destined for a group of devices was not possible. However, during the past few years, a new set of applications has emerged. These applications use multicast transmissions to enable efficient communication between groups of devices. Data is transmitted to a single multicast IP address and received by any device that needs to obtain the transmission. There are business applications that require a multicast transmission mechanism to enable bandwidth-efficient communication between groups of devices where information is transmitted to a single multicast address and received by any device that wishes to obtain such information [1]. Usually, there are classes of applications that require streaming of information to a set of end users. This can be done using IP multicast. It is well defined that IP multicast is designed to support communication between one source and multiple destinations. IP multicast protocols enable efficient distribution of data, voice and video streams to a number of end users.

Multicasting over IP network presents many challenges related to reservation of resources and maintaining quality of Service (QoS). Implementing IPTV requires unicasting and multicasting of content to thousands of customers while maintaining QoS. With the increasing of IPTV customers, products for delivery of IPTV with large scalability have emerged in the market [2].

In this paper we will introduce the unicast versus multicast for video streaming and the benefits of using multicast for offering IPTV services with high QoS. Also in this paper we will explain the benefits of streaming IPTV with multicast in core and access network. At the end, the role of IGMP protocol for IPTV streaming is explained into detail, including here IGMPv1 and IGMP v2 protocols.

2 Basic concepts for unicast and multicast

Unicast streaming is a one- to-one connection between a server and a client. This means that each client gets a separate stream and only if they request it. Unicast streaming works either for live streaming or on demand streaming, eg. VoD (Video on Demand) [3].

2.1 Streaming content with unicast

When a packet is sent between two hosts, and when there is one sending process and one receiving process only, in this case we have to do with unicast. For each client an individual packet stream is setup (from the server). Unicast routing protocols build routing tables by exchanging information about destination networks. The main principle of
unicast is when one application Server sends 1 copy of data for each host, this is shown better in figure 1:

![Figure 1. Demonstration of unicast routing](image)

The problem with unicast arises when you want to send a stream of data to many users. In that case you need to send this stream as many times as there are users, so this requires a massive amount of bandwidth. By using unicast streaming, one copy of the stream is sent for each subscriber. In this case it is used massive bandwidth.

2.2. Streaming content with multicast

IP multicast is a bandwidth-conserving technology that reduces traffic by simultaneously delivering a single stream of information to potentially thousands of users. Applications that take advantage of multicast include video conferencing, corporate communications, distance learning, and distribution of software, stock quotes, and news. IP multicast delivers application source traffic to multiple receivers without burdening the source or the receivers while using a minimum of network bandwidth. The principle of multicasting technology is shown in figure 2. Multicast packets are replicated in the network at the point where paths diverge by the routers enabled with Protocol Independent Multicast (PIM) and other supporting multicast protocols, resulting in the most efficient delivery of data to multiple receivers. Most multicast routing protocols use a “reverse path forwarding mechanism”. This implies: duplication of multicast packets by routers. The main principles of multicast functioning are as below:

- Server sends 1 copy of data to a group of users
- Network nodes replicate at last possible hop

![Figure 2. Demonstration of multicast streaming](image)

Multicast is based on the concept of a group. A multicast group is an arbitrary group of receivers that expresses an interest in receiving a particular data stream. Hosts that are interested in receiving data flowing to a particular group must join the group using IGMP protocol that we will explain later in this paper. In order to receive stream, the hosts must be member of the group. The membership of a host group is dynamic; that is, hosts may join and leave groups at any time.

3 IP multicasting

There is no restriction on the location or number of members in one host group, but membership in a group may be restricted to only those hosts possessing a private access key. A host may be a member of more than one group at a time. A host need not be a member of a group to send datagrams to it. A host group may be permanent or transient. A permanent group has a well-known, administratively assigned IP address. It is the address, not the membership of the group that is permanent; at any time a permanent group may have any number of members, even zero. A transient group, on the other hand, is assigned an address dynamically when the group is created, at the request of a host. A transient group ceases to exist, and its address becomes eligible for reassignment, when its membership drops to zero.

The Internet Assigned Numbers Authority (IANA) controls the assignment of IP multicast addresses. IANA has assigned the IPv4 Class D address space to be used for IP multicast. Therefore multicast devices use Class D IP addresses (as destination addresses only!) to communicate. These addresses are contained in the range encompassing 224.0.0.0 through 239.255.255.255.

A small number of MC IP addresses is permanently reserved, but all the other addresses are available. The Internet is divided into several
multicast domains. Within each domain one can theoretically use the full range of transient class D IP addresses. There is a DHCP-like functionality within such a domain that allocates IP addresses (and registers which class D IP addresses are in use). It is possible to have inter-domain multicasts, but then you need to have a mapping between multicast addresses within the respective multicast domains. In contrast to standard IP unicast traffic forwarding, the mapping between the IP multicast destination address and the data-link address is not done with ARP. Instead, a static mapping has been defined. In an Ethernet network, multicasting is supported if the high-order octet of the data-link address is 0x01'. The IANA has reserved the range 0x01005E000000' through 0x01005E7FFFFF' for multicast addresses. This range provides 23 usable bits. The 32-bit multicast IP address is mapped to an Ethernet address by placing the low-order 23 bits of the Class D address into the low-order 23 bits. Since the high-order five bits of the IP multicast group are ignored, 32 different multicast groups are mapped to the same Ethernet address. Because of this non-unique mapping, filtering by the device driver is required.

4 Streaming content with multicast in core and in both core and access network

For core network design it is considered that the network is an IP backbone network. There are two types of approaches that are considered for designing core network for IPTV streaming. The main task of core network is to deliver IPTV traffic from SHOs (Super Home Offices) to VHOs (Video Home Offices). At IP based core network the unicast traffic is routed by using OSPF or IS-IS routing algorithm. These algorithms route traffic over the shortest path between source and destination, based on the administrative weights assigned to each network link.

IP multicast is efficient way to meet with new services and applications of internet. The overall bandwidth consumption is reduced by using multicast in core network. In this aspect, it is able to reduce the load on all the servers of IPTV platform, since the servers have to send one packet for link, instead of multiple packets to multi users. Using multicast in core network also has fundamental role in network processing. Finally, we can say that the advantageous of applying multicast in core network is that IP multicasting avoids multiple copies in core, but still contains multiple copies in access network (see Figure 3).

To avoid multiple copies in the access network it is needed to deploy multicast in core and access network. Multicasting at all stages (core and access network) eliminates replicated broadcast traffic in the network. In figure below (see Figure 4) we can see better multicasting applied in core and access.

5 Overview of IGMP protocol; IGMP v1 and IGMP v2 deployment in IPTV architecture

Before discussing the options available in a multicast-enabled access network, it is first helpful to understand how IGMP operates [7]. Full support for IP multicasting, allows a host to create, join and leave host groups, as well as send IP datagrams to host groups. It requires implementation of the IGMP and extension of the IP and local network service interfaces within the host. The sections below give a brief overview of IGMPv1 and IGMPv2 when used in IPTV architecture. Here we will explain shortly these IGMP versions and also we will analyze the scenario of these versions to see communication scenario between service routers and hosts in one LAN.
5.1. IGMP v1 scenario for IPTV streaming

The main requirement in IPTV networks is the ability to deliver high-quality video streams to each customer. IP multicast is used to allow the network to copy and forward copies of the same source stream to a large number of viewers. The set-top box (STB) sends IGMP join messages that terminate at an Access Node (AN) or Services Router (SR). In turn, the AN or SR responds by forwarding the requested multicast group (television channel) to the subscriber who made the request [5].

The IGMP was defined in order to allow a host computer to select a stream from a group of multicast streams a user desires to connect to. There are 3 versions of IGMP protocol. In this paper we will analyze version 1 and version 2.

In a case of IGMP version 1 we have 2 types of messages of concern to the host:

1. Host membership queries
   - Router sends query when it receives the multicast stream from IPTV platform
   - Just one router in the LAN sends queries

2. Host membership reports
   - Host sends membership report to receive multicast stream
   - Response to membership query that is send from router

In the figure below (see Figure 5) we will present the IGMP v1 protocol and the communication scenario between host and Service router using this protocol.

1. IGMP query: Multicast routers send Host Membership Query messages to discover which host groups have members on their LAN.
2. IGMP report: Hosts respond to a Query by generating Host Membership Reports, reporting each host group to which they belong on the network interface from which the Query was received.
3. Start sending data: Multicast routers send Queries periodically to refresh their knowledge of memberships present on a particular network.
4. IGMP query: Queries are normally sent infrequently (no more than once a minute) so as to keep the IGMP overhead on hosts and networks very low. However, when a multicast router starts up, it may issue several closely-spaced Queries in order to quickly build up its knowledge of local memberships.
5. No IGMP report: When a host joins a new group, it should immediately transmit a Report for that group, rather than waiting for a Query, in case it is the first member of that group on the network. To cover the possibility of the initial Report being lost or damaged, it is recommended that it be repeated once or twice after short delays.
6. Stop sending data

As we can see, IGMP version 1 doesn't have a leave mechanism. When a host does not want to receive the IGMP traffic any more, it just quits silently. As conclusion, in a case of IGMP v1, hosts can join multicast groups. There were no leave messages, routers were using a time-out based mechanism to discover the groups that are of no interest to the members [6].

5.2. IGMP v2 scenario for IPTV streaming

IGMPv2 allows group membership termination to be quickly reported to the routing protocol, which is important for high-bandwidth multicast groups. IGMPv2 querier generates two types of query messages:

- General query message: for obtaining all possible multicast membership information
- Group specific query: for determining whether there are any members for a specific multicast group.

In the section below, it is described step-by-step IGMP v2 communication scenario between hosts and service routers:

1. An IGMPv2 host sends a report on joining a multicast group. It generates a report after a random delay when it receives a generic query message. A host that responds to a generic query message maintains information, as it is the last host to reply the query.
2. A last host sends a leave group message when it is no longer a member of the multicast group.
3. Start sending data
4. When an IGMPv2 querier receives a leave group message for multicast group, it generates a group specific query to check whether there are any other member hosts for that particular group.
5. No answer, stop sending data

See figure 6 detailed description for abovementioned scenario:

![Figure 6. IGMP v2 Scenario](image)

In the case of IGMP v2, host sends leave message, If there is no response to the group Query, the group is closed. Leave messages were added to the protocol. IGMP v2 allows group membership termination to be quickly reported to the routing protocol, which is important for high-bandwidth multicast groups and/or subnets with highly volatile group membership [6].

**Conclusion**

With the fast growth of broadband network, a lot of services like triple play services are increasingly required by customers. The unicast is no longer adequate for video services such as IPTV services. As a result, the scientists are looking for new advanced technology in order to use efficiently bandwidth. Thus, for delivering IPTV services is used multicasting technology. IP multicast can preserve bandwidth by sending multicast groups to a lot of users. This is critical in xDSL networks which are designed to support limited number of TV channels. The necessity of multicast for IPTV streams is especially for conserving bandwidth and reducing burden on transmitters. Here in this paper we have analyzed into details unicast and multicast technology, especially the methodology of streaming content with multicast and the benefits of using multicast technology in the core and access network. As a conclusion, using multicast in core network avoids multiple copies in core, but still we have multiple copies at the access network. That’s why it is necessary to use multicast technology in core and access network in order to use efficiently bandwidth and maintaining QoS. So, in order to provide IPTV with high QoS multicast mechanism is more than essential.

In order to allow hosts to select streams from group of multicast stream, there is a need for using IGMP protocol. In this paper we have analyzed also the communication scenarios for IGMPv1 and IGMP v2.

**References:**