A Bandwidth Reservation Method for IPTV Service

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***Abstract*— A growth of high speed Internet increases network traffic and applications that use voice, data, and multimedia services. Among those, Internet Protocol TeleVision (IPTV) service is rapidly proliferating all over the world. However, network infrastructure cannot accommodate the growth of IPTV. Therefore, this study suggested a bandwidth reservation mechanism using a traditional protocol to achieve a more stable IPTV service. We referenced the Multiple Stream Reservation Protocol (MSRP) that is a bandwidth reservation protocol in IEEE 802.1AVB and implemented a similar reservation mechanism in IPTV service environment; however, but our own mechanism improved the bandwidth reservation fail situations that are not supported by the original MSRP. Therefore, the proposed method is more stable for bandwidth reservation in the IPTV service environment. We examined the proposed method with network simulator, OPNET, and compared an end-to-end delay via the original IPTV service and with the end-to-end delay using our bandwidth reservation.**

Keywords - QoS; bandwidth reservation; IPTV

I. Introduction

The growth of high speed Internet increases network traffic and applications that use voice, data, and multimedia services. Further, depending on the development of terminal devices capable of playing multimedia - such as Mp3 players, Portable Multimedia Players (PMPs), smart phones, and navigation etc. - many network application services have been created. Among those, Internet Protocol TeleVision (IPTV), which is highly regarded as a killer application service, is rapidly increasing in the world. Sufficient network resources are needed for supporting IPTV services [1]. However, the current network resource is insufficient due to heavy Peer-to-Peer (P2P) traffic and other traffic getting into network; further, there are times when average network service is impossible to achieve due to malicious traffic such as Distributed Denial of Service (DDoS). To achieve a stable IPTV service against harmful traffic, network bandwidth reservation is needed. The current IPTV service offers guaranteed Quality of Service (QoS) by Internet Service Providers (ISPs) to subscribers, but QoS is not guaranteed from subscriber networks to each user because the network transmission policy is best-effort [2].

The Institute of Electrical and Electronics Engineers 802.1 Audio/Video Bridging Task Group (IEEE 802.1 AVB TG) is carrying out research among Ethernet-based digital media devices. First, high quality synchronization services are provided among several digital media devices in LANs. Second, there is a mechanism to make reservation resources for each service in addition to sets of default rules for managing resources. A third kind of research is on a traffic forwarding method through reserved bandwidth [3]. Our study is aimed to achieve Multiple Stream Reservation Protocol (MSRP) which is a kind of bandwidth reservation applied to the IPTV service using Internet Group Management Protocol (IGMP). However, MSRP does not handle some failed bandwidth reservation situations in the IPTV service environment. Therefore, we improved the original MSRP to handle failed bandwidth reservation situations, and our proposed mechanism can support higher QoS than traditional IPTV service.

The remainder of the paper is organized as follows. In Section II, we introduce the existing bandwidth reservation methods such as Resource Reservation Protocol (RSVP), IEEE 802.1p, and MSRP. In Section III, we propose processes for various situations related to bandwidth reservation and reservation withdrawal with using IGMP, and in Section IV, we introduce the simulation and numerical results in. Section V presents the concluding remarks.

II. Related Work

A. *RSVP*

The Resource ReSerVation Protocol (RSVP), a kind of Integrated Service (IntServ), is a reservation mechanism executing on the transport layer. RSVP can be used by either hosts or routers to request or deliver specific levels of quality of service (QoS) for application data streams or flows. RSVP defines how applications place reservations and how they can relinquish the reserved resources once the need for them has ended. RSVP operation will generally result in resources being reserved in each node along a path. RSVP does not transport application data but is rather an Internet control protocol, like ICMP, IGMP, or the routing protocol [4]. RSVP also provides receiver-initiated setup of resource reservations for multicast or unicast data flows with scaling and robustness. Figure 1 shows the reservation process via RSVP.

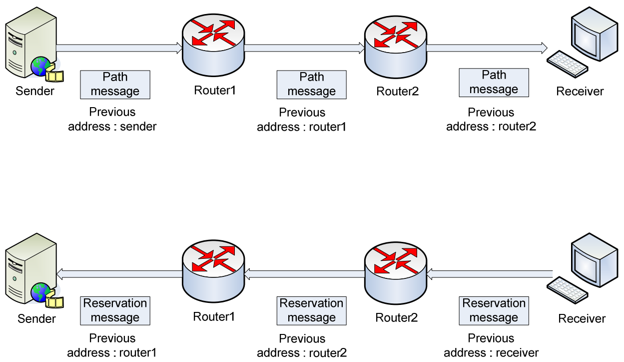

Figure 1. Reservation mechnism with RSVP

Although RSVP can control the QoS level for application data streams or flows per specific users, every device must support RSVP and store the reservation state in each node along the path [4]. The implementation of RSVP is difficult because the path of traffic is not constant on the Internet. For this reason, RSVP was little used. To solve the problem of RSVP, the Differentiated Service (DiffServ) was proposed. DiffServ provides adequate QoS via prioritizing traffic.

B. IEEE 802.1p

One type of DiffServ, IEEE 802.1p that is operated at the data link layer, processes frames according to their priority on the Ethernet [5]. IEEE 802.1p defines eight different classes of available service, usually expressed through the 3-bit priority field. The most important is priority 7 which corresponds to the network control frame, and priority 0 which corresponds to the best effort traffic that is the least important frame. If some frame belongs to the multimedia service, then its priority is 4 or 5. In this case, the multimedia frame has higher priority than other best effort frames, so multimedia frame could be guaranteed QoS. Figure 2 shows the structure of Ethernet frame using IEEE 802.1p.

However, IEEE 802.1p has two problems [6]. First, when two or more frames having the same priority arrive at the switch at the same time, some of these frames are discarded due to the limited queue size on the switch. If the time-sensitive frame is discarded, then large jitters occur and the media cannot be guaranteed QoS. Second, the more the hop count increases, the more the potential delay of time-sensitive frame increases due to the time-sensitive frame of other applications. The reason that transmission delay increases is due to accumulating delay by competition with the same priority frames and the effects of lower priority frame for non-preemption. Therefore, DiffServ is inadequate for specific applications.

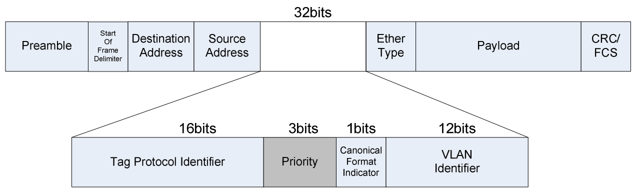

Figure 2. The frame structure using IEEE 802.1p

C. MSRP

MSRP that is being studied in IEEE 802.1 AVB TG is used in Ethernet and works by making a sub spanning tree for specific traffic [7]. MSPR reserves bandwidth on the Ethernet, so the reservation path is fixed. In addition, MSRP does not cause delays by other traffic because MSRP is a kind of IntServ.

In MSRP, a Talker means that the node can serve multimedia streaming to other nodes on the LAN, while a Listener receives multimedia streaming service from a Talker. MSRP starts a reservation when Talker announces that they can serve a multimedia service, or Listener announces that they want to receive a multimedia streaming service in the LAN. MSRP uses five types of messages. Each type is presented in Table 1.

TABLE I. MSRP MESSAGE TYPES

Message		Description
Talker	Advertise	Advertise for a stream that has not encountered any bandwidth or other network constraints along the network path from the Talker.
	Failed	Advertisement for a Stream that is not available to the Listener due to bandwidth constraints or other limitations somewhere along the path from the Talker.
Listener	Asking Failed	One or more Listeners are requesting attachment to the Stream. None of those Listeners are able to receive the Stream because of network bandwidth or resource allocation problems.
	Ready	One or more Listeners are requesting attachment to the Stream. There is sufficient bandwidth and resources available along the path(s) back to the Talker for all Listeners to receive the Stream
	Ready Failed	Two or more Listeners are requesting attachment to the Stream. At least one of those Listeners has sufficient bandwidth and resources along the path to receive the Stream, but one or more other Listeners are unable to receive the stream due to network bandwidth or resource allocation problems.

The Talker creates a Talker Advertise declaration message to announce to other nodes on the LAN and update

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its MSRP table. A Talker Advertise message includes the MAC address of the Talker, declaration type, required bandwidth, etc. The bridge port 0, which receives the Talker Advertise message, then registers it in its MSRP table and sends it to other ports on the bridge. The bridge port 1 that receives the Talker Advertise message by bridge port 0 registers the message in its MSRP table and compares the requirement bandwidth of the message with its available bandwidth. If the available bandwidth is larger than the required bandwidth, then the message is forwarded to the other node. Otherwise, the message is changed to Talker Failed message and forwarded.

When A Talker Advertise message arrives at a Listener, if the Listener wants to receive the Talker's service, then the Listener generates a Listener Ready message and sends it to the Talker. A Listener Ready message has only the StreamID of the Talker; StreamID consists of the MAC address of the Talker and an integer number. Bridgeport 1, which receives the Listener Ready message, reserves the required bandwidth, if port 1 has sufficient available bandwidth. When the bandwidth reservation is successful at port 1, the Listener Ready message is forwarded to the Talker by MSRP attribute propagation. The Listener Ready message arrives at the Talker, and the Talker then compares its MSRP table with the streamID in the Ready message. If the Listener Ready message is associated with a stream that the Talker can supply, then the Talker can immediately start the transmission for this stream. Figure 3 illustrates the MSRP reservation success process.

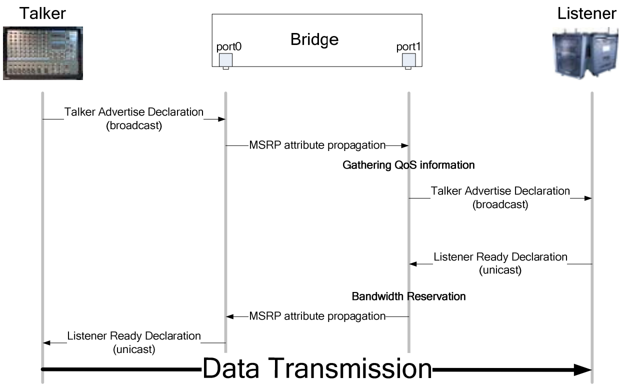

Figure 3. Bandwidth reservation success process

In the cases of reserved bandwidth withdrawal, the Talker stops streaming or the Listener declines to receive the stream of Talker service. If the Talker wants to stop the services, then the Talker generates a Talker Failed message and sends it to the Listener, who in turn stops transmitting the stream. The bridge port 0, which receives the Talker Failed message, sends to some ports that have already reserved bandwidth for the stream of the Talker. The bridge port 1 that receives the Talker Failed message by port 0 returns the reserved bandwidth and forwards the Talker Failed message. The Listener that receives Talker Failed message deletes the streamID of Talker Failed message in its MSRP table. In the case of bandwidth reservation failure, the outgoing port of bridge has insufficient bandwidth than the required bandwidth when the Talker Advertise message is forwarded. In this case, the Talker Advertise message is changed to Talker Failed message and forwarded. Then, the MSRP defines a bandwidth reservation/withdrawal and bandwidth reservation failed in the Ethernet.

However, the bandwidth reservation fail situation was able to occur in MSRP. That can happen such as the state of the listener and available bandwidth is insufficient when not only the Talker Advertise message arrives but also when the Listener Ready message arrives at the port. MSRP, which has not been researched until now, can process only a few situations in which bandwidth reservation failed, so it is not effective in a QoS guaranteed environment. When a number of services share limited resources, bandwidth reservation failure will occur; this problem must be resolved.

III. IGMP-BASED BANDWIDTH RESERVATION

The Internet Group Management Protocol (IGMP) is a communications protocol used by hosts and adjacent routers on IP networks for the purpose of establishing multicast group memberships. IGMP is used to join and leave multicast group memberships. The latest IGMP is version 3, but we use IGMP version 2, which is widely used. We suggest a bandwidth reservation using IGMP, which is a similar MSRP mechanism, and implemented a bandwidth reservation/withdrawal process on IPTV multicast group join and leave.

- In the case of terminal node send Membership Report message

When a Membership Report message sent by a terminal node sends arrives at multicast-supported router, the router starts a streaming service to the node. As a result, intermediate device receives the Membership Report message, and the device needs to reserve bandwidth. When intermediate devices receive a Membership Report message, the device checks available bandwidth at incoming port. If the available bandwidth is can support the demanded multicast stream bandwidth of terminal node, then the device reserves the demanded bandwidth and forwards a Membership Report message. When available bandwidth of the device port is insufficient, the device discards the Membership Report message. In traditional IGMP, the intermediate device receives a Membership Report message, and the device broadcasts (or multicast) the message to restrict unnecessary traffic. However, we use a Membership Report message for bandwidth reservation, and the device does not broadcast but only sends the message to the multicast router side. Therefore, another terminal node sends a Membership Report message that is about the same multicast group for bandwidth reservation. We show this process in the Figure 4.

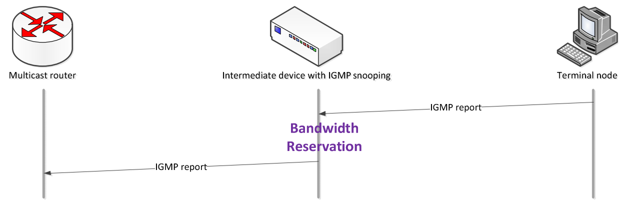

Figure 4. Bandwidth reservation process with IGMP Membership Report message

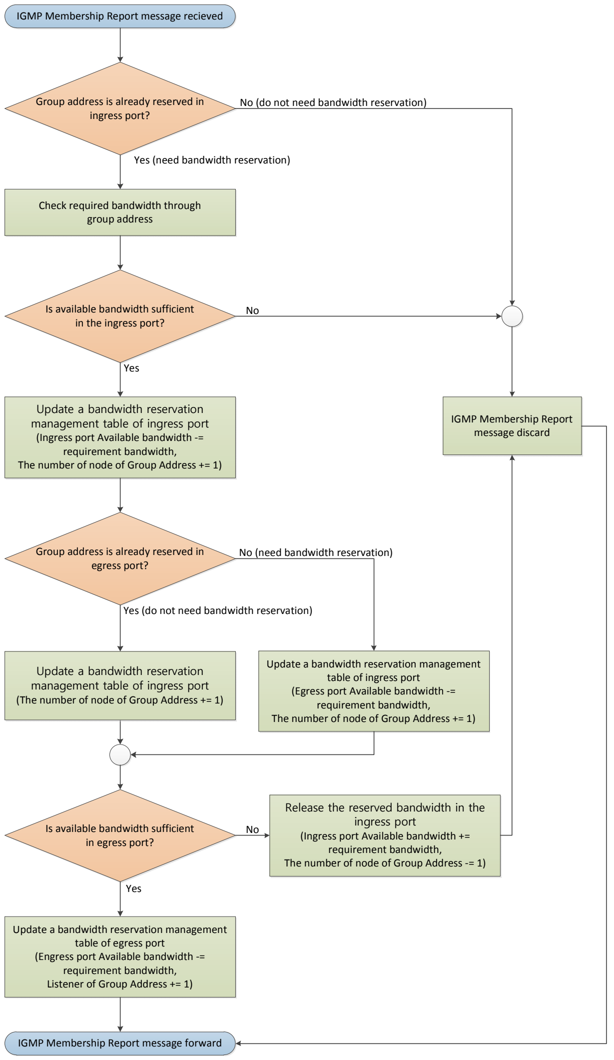

Figure 5. Bandwidth reservation flow chart in intermediate device

A bandwidth reservation process in the intermediate device is as follows. First, it checks that the group address of Membership Report message is reserved on the ingress port. When the group address is already reserved, we only update the number of terminal node of the group address. When the group address is not reserved, the device check required bandwidth of the group address, then check whether available bandwidth is sufficient or insufficient for support required bandwidth. If the available bandwidth is insufficient, then it is regarded as bandwidth reservation failure, and the device discards the Membership Report message and sends a message that notifies that the required service cannot be provided due to insufficient bandwidth to the terminal node. On the other hand, if the available bandwidth is sufficient, then the device updates the bandwidth reservation management table of ingress port and allocates the bandwidth. The device checks the bandwidth reservation management table of egress port. If the group address is not reserved in the egress port, then we sue the same process for egress port as that used for ingress port. If the group address is already reserved in the egress port, then the device forwards the message to the multicast router side. However, if the available bandwidth is insufficient in the egress port, then release the reserved bandwidth in the ingress port and discard the message. We show this process in Figure 5.

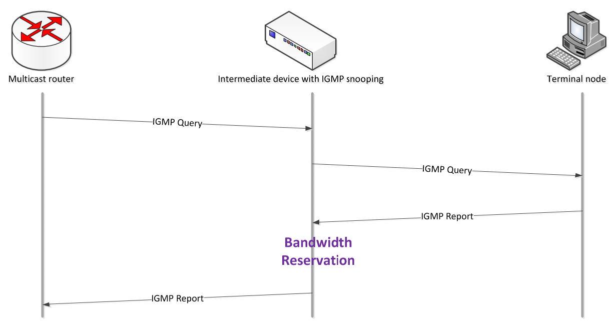

Figure 6. Bandwidth reservation process via IGMP Membership Query message

- In the case of multicast router sending the Membership Query message

In this case, a terminal node that wants to join a multicast group or already has joined a specific multicast group, sends a Membership Report message to the multicast router for bandwidth reservation. This case is the same as that of the previous case in that the terminal node sends a Membership Report message. Figure 6 is shows the bandwidth reservation process via IGMP Membership Query message

- In the case of terminal node sending a Leave Group message

In this case, the terminal node does not receive a multicast stream any more, and an intermediate device needs to release the bandwidth of multicast stream of the terminal node. We define this process as “bandwidth withdrawal”. The device forwards the Leave Group message to the multicast router side after bandwidth withdrawal. The router that receives the Leave Group message sends a Membership Query message with the group address of the Leave Group message to other terminal nodes. After this, nodes that have received the Membership Query message via multicast send a Membership Report message, and this is similar to that in the case of terminal node sending a Membership Report message. Figure 7 shows the bandwidth reservation process

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via IGMP Leave Group message, and Figure 8 shows the bandwidth withdrawal process in an intermediate device.

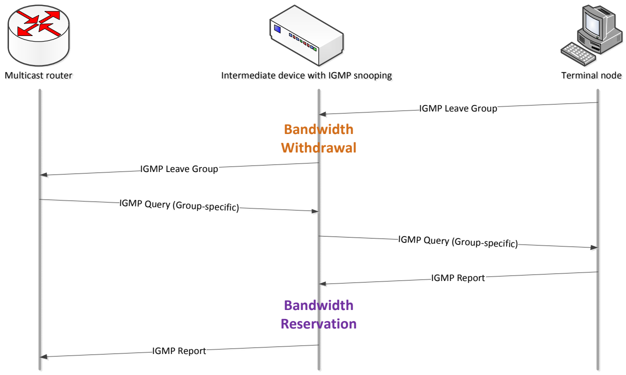

Figure 7. Bandwidth reservation process via IGMP Leave Group message

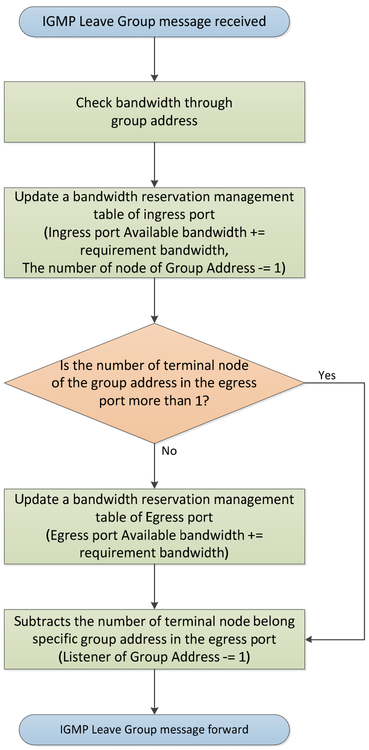

Figure 8. Bandwidth withdrawl flow chart in intermediate device

The bandwidth withdrawal process is as follows. When the ingress port of the device receives a Leave Group message, the device check the allocated bandwidth for group address in the message and then updates the bandwidth reservation management table of the ingress port and releases the bandwidth. If the number of terminal node of the group address specified in the Leave Group message is one, then the bandwidth reservation management table of the egress port also updates as according to the ingress port. If the number of terminal node of the group address in the egress port is more than one, then the device only subtracts the number of terminal node in the egress port, and forwards the Leave Group message.

IV. SIMULATION RESULT

To show the efficiency of the proposed bandwidth reservation via IGMP, we used the network simulator OPNET. We compared the traditional IGMP with our suggestion in terms of multicast streaming. We set up a network environment using 6 L3 switches that are intermediate devices, 10 terminal nodes, and the load time-sensitive traffic, non-time-sensitive traffic at each link. Further, we used time-sensitive traffic with voice and video traffic. Therefore, each node sends the Membership Report message to the multicast router at different time intervals. Figure 9 shows our network topology.

The traffic of each source is 100Mbps, and we set the outgoing stream frame size of each source to 125 Kbytes. For the analysis of end-to-end delay is according to network load. Therefore, we set different join times for each terminal node, as is shown in Table 2.

TABLE II. JOIN TIME OF EACH TERMINAL

Terminal node	Join time (sec)	Terminal node	Join time (sec)
User1	75	User5	85
User2	80	User6	90
User3	80	User7	90
User4	85		

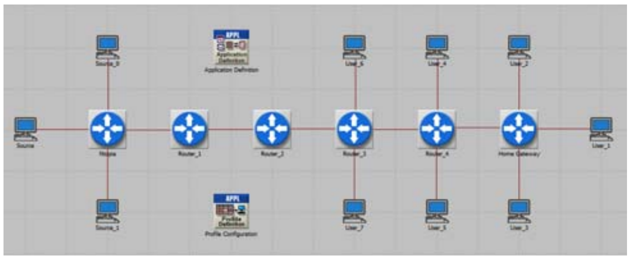

Figure 9. The network simulation topology

The traffic generation rate and characteristic follow that voice is Expedited Forwarding (EF), video is Assured Forwarding (AF), and non-time-sensitive traffic is Best Effort (BE). The EF traffic is used to transmit voice data, and it is a Constant Bit Rate (CBR) in the ATM network. The AF traffic is video data type such as MPEG-1, MPEG-2 and H.264. It is used by Video on Demand (VoD), video conferencing, etc. The AF traffic regards bandwidth with great importance, but it is less sensitive to delays than EF traffic. The BE traffic is used by legacy Internet services such as web services, e-mail and FTP. The BE traffic does not need real time transmission. Therefore, Walter et al. discovered that AF and BE traffics have self-similarity characteristic [8]. Figure 10 and Figure 11 show an end-to-end delay with traditional IGMP, and after bandwidth reservation using IGMP, respectively.

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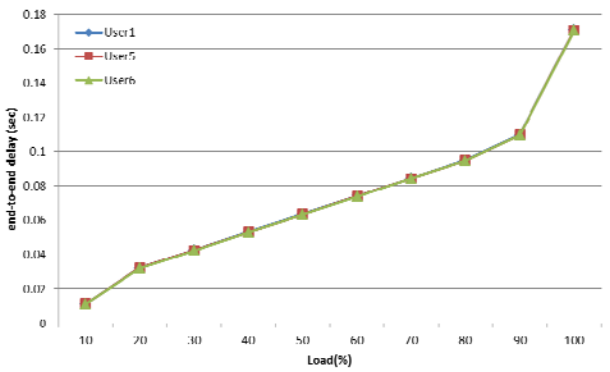

Figure 10. End-to-end delay with traditional IGMP

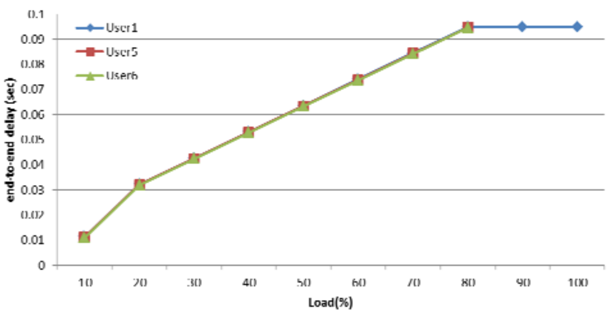

Figure 11. End-to-end delay after bandwidth reservation using IGMP

In Figure 11, the traffic node is over 90%, and multicast traffics, except User1, do not transmit because *User1* had the first IPTV streaming service after bandwidth reservation, while *User5, and User6* cannot IPTV the streaming service because the available bandwidth is insufficient due to bandwidth reservation by *User2 and User3*. Therefore, the QoS of User1 is guaranteed.

V. Conclusion and Future Work

Nowadays, as network infrastructure and device continue to advance, various network-based applications appear among those applications, IPTV is increasing rapidly worldwide. To support IPTV services, sufficient network resources are required. This paper proposed the MSRP mechanism to reapply to the IPTV environment. We applied a bandwidth reservation mechanism using IGMP message. The bandwidth reservation is similar to that of MSRP, and we improved the network resource efficiency to process the wasted bandwidth due to bandwidth reservation failure. We simulated our proposed method via OPNET, and the network simulator confirmed that the end-to-end delay of multicast traffic is shorter than that of the traditional method.

In the following research, we expect longer channel zapping time than that of the traditional method because of the additional bandwidth process. Therefore, we need to improve channel zapping time to match that of traditional IGMP, and support suitable IPTV service. Furthermore, when wired/wireless devices join the same streaming service, a study is needed to achieve a bandwidth reservation mechanism to guarantee QoS among them.

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