

# A Fast Channel Switching Method in EPON System for IPTV Service

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**Abstract.** This paper presents a fast channel switching method in Ethernet Passive Optical Network (EPON) system for IPTV service. Fast channel switching is one of the important features of successful IPTV systems. Users surely prefer IPTV systems with small channel switching time rather than a longer one. Thus a channel switching control module and a channel/permission list in EPON system's ONU or OLT is designed. When EPON system receives channel switching message from IPTV end user, the channel switching control module will catch the message and search the channel list and permission list maintained in EPON system, then got the matching parameter of EPON for the new channel. The new channel's data transmission will be enabled by directly updating the optical filter of the ONU that end user connected. By using this method in EPON system, it provides a solution for dealing with channel switching delays in IPTV service.

**Keywords:** EPON, IPTV, QoE, Channel switching.

## 1 Introduction

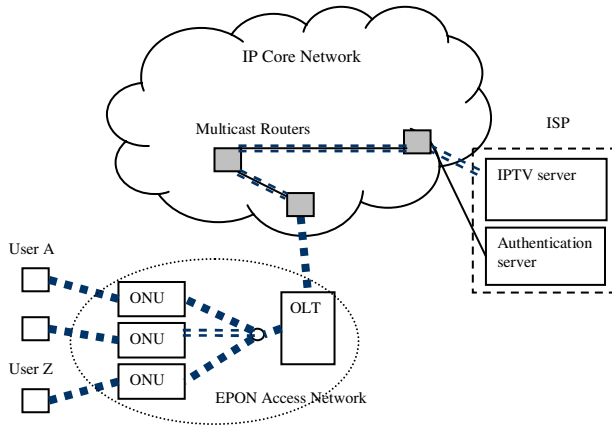
Broadband services in Internet like IPTV, video phone, on line gaming and so on, have become the most important services for both carriers and end users. IPTV service [1], as one of the most important triple play services run over broadband network, will change the end user's entertainment style from cable TV to TV over Internet, from broadcast TV to inter-active TV enjoyment.

EPON system [2], standardized in IEEE, can provide up to 1Gbps bandwidth to end user. As one of the solutions for broadband access network, it is recognized one of the final solutions for 'last 1 mile access'.

Figure 1 is a typical system of IPTV service running over broadband IP network with EPON access network. In this system, there are IP core network and EPON access network. In the EPON access network; the Optical Line Terminal (OLT) and the Optical Network Unit (ONU) connected by fibers are the main components. The IPTV services are provided from ISP's IPTV servers to the end users through the

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**Fig. 1.** IPTV/EPON system

whole network. The dotted blue lines in figure 1 are video packets route. The IPTV server connects with multicast routers in the IP core network. The video packets are sent through this core network to the access network (EPON) by multicast packets. In EPON, the packets are broadcast from the OLT to the ONUs in MAC layer with the specific address of the Logical Link Identifier (LLID).

Channel switching time is one of the key features that determine the Quality of Experience (QoE) of IPTV service for end user. In the traditional cable TV system, it is around 100ms [4]. The end user almost can hardly notice the short period of interruption while they switch from one channel to another channel because of the nature of human eyes. So how to assure a small enough channel switching time in IPTV services?

In this paper, a fast channel switching method in EPON for IPTV service is presented. Chapter two includes the mathematical analysis for the factors that impact the channel switching time. Chapter three includes the detail description of the presented method. Chapter four includes the test system and the test result analysis. And the last chapter provides a final conclusion.

## 2 Problem Analysis

In figure 2 below, the channel switching event is divided into several sub-events in sequence. Thus the total channel switching time can be divided to several parts accordingly.

In figure 2, Event 0 is the user pushes button on remote controller, it needs time  $T_0$ . Event 1 is the STB processing and sending IGMP leave message for old channel and IGMP join message for new channel. It needs time  $T_1$ . Event 2 is IGMP processing in ONU. It needs time  $T_2$ . Event 3 is IGMP processing in OLT. It needs time  $T_3$ . Event 4 is IGMP processing in edge IPTV server. It needs time  $T_4$ . Event 5 is IGMP processing in remote IPTV server. It needs time  $T_5$ . Event 6 is first I frame

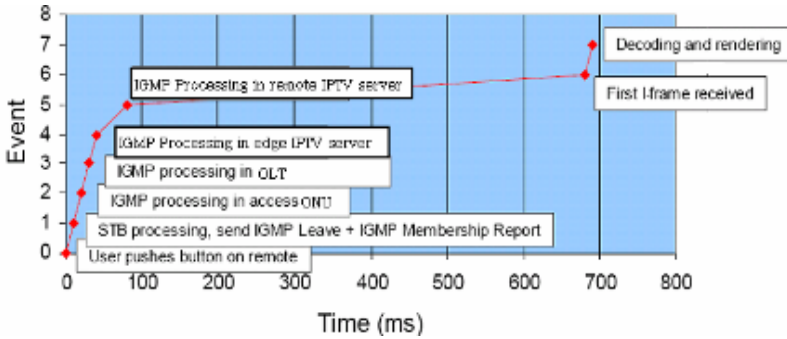


Fig. 2. Channel switching time

received. It needs time T6, Event 7 is decoding and rendering. It needs time T7. The channel switching time should be the summation of T1 to T7:

$$T_{\text{ChannelSwitching}} = T_0 + T_1 + T_2 + T_3 + T_4 + T_5 + T_6 + T_7$$

From T1 to T7, each has different feature and impact to the total channel switching time. In IPTV service, since both video data packets and control messages are transported over IP packet. And the TCP/IP system is a kind of “best effort” system. Even the core networks assure some level of QoS since they are engineered; Time for sending and receiving message is affected much by the IP network traffic status. Thus it can not assure key features for the time sensitive applications.

T5 is the longest delay parameter in all time parameters, because it will be affected by the traffic status of the core network.

IGMP (Internet Group Management Protocol) or MLD (Multicast Listener Discovery) leave/join delay (T1 to T5) has a direct impact on channel switching delay. As the analysis in paper ‘Validating IPTV Service Quality under Realistic Triple Play Network Conditions’ [5] said, acceptable channel switching delay is generally considered to be approximately 1 second total, end-to-end. A channel switching time of 100~200 ms is considered by viewers to be instantaneous. To keep overall channel switching delay within one second, the target multicast leave/join delay of each network component needs to be within the 10-200 ms range. Thus T1 to T5 should be within 10-200 ms range.

Increasing number of subscribers will make a strong impact to both network traffic and the channel switching time. As the analysis in paper ‘Channel Change Performance Testing’ [6] found, after increasing the subscribers number and hence the load on the multicast network, it increased the subscriber’s perceived Join/Leave latencies by 70% and 65% respectively.

To solve or avoid the three problems above, a fast channel switching method in EPON is presented in this paper. EPON system can control multicast traffic for end users in access network. The downlink traffic is broadcasted from OLT to all end terminals (ONU), the ONU uses a filter to select and transport the corresponding traffic to the end user.

By doing channel switching control in EPON, it will reduce or avoid the impact of core network's traffic status. Processing IGMP message will also reduce the impact of IGMP message delay. This method collects information of all subscribers for cooperation but not make compete in subscribers, thus it decreases the impact of increasing of subscribers to network traffic and channel switching time.

### 3 The Fast Channel Switching Method

In the fast channel switching method in EPON system, a channel switching control module and a channel list module (in ONU or OLT) is designed. In case of authentication to different ISPs, a permission snooping module and a permission list are also designed.

The channel list is maintained and updated by using IGMP snooping function. The permission list is maintained and updated by the permission snooping function. The Permission snooping module communicates with the ISP's authentication servers to get authentication information.

When EPON system catches the message for channel switching from end user, the channel switching control module will search the channel list maintained in EPON system, and got the matching parameters for the new channel. The new channel's data transmission will be enabled by directly updating the optical filter of the ONU that the end user connected.

#### 3.1 The Fast IPTV Channel Switching Processing Procedure

With one user is watching one channel at a time, for thousands or even millions of users in the same access network, there are more than one channel's traffic available to end users. These entire video traffic uses multicast inside the network. For example, when User A is watching channel 1, User X in the same access network might watch channel 2 at the same time. So when the end user A wants to switch from channel 1 to channel 2, the traffic of channel 2 to User X can be sent to User A by multicast control in the access network. EPON system controls this in MAC layer with a faster response and processing speed by updating the optical filter.

As shown in figure 3, the channel switching processing is:

1) EPON system catches the user's IGMP 'JOIN' request for switching to a new channel. Then in GMP EPON frame, there are fields of new channel's group address and the "TYPE" field indicating of joining a new group: 2. such parameters will be checked and recorded for next step.

2) Channel switching control module checks the channel list with the index of group address.

3) If there is a record in its channel list (the access network has the traffic already), go to next step. If no records in the channel list, go to step 6.

4) Get Logical Link Identifier (LLID [7]) of the new channel from channel list.

5) Update the LLID filter of the ONU with the new channel's LLID number. So that the new channel's traffic can go through the ONU's filter to the end user.

6) Forward the IGMP request to IGMP servers (IGMP router, IPTV servers) to finish message procedure with ISP.

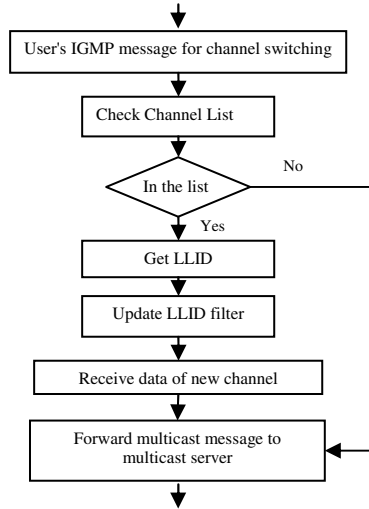


Fig. 3. Message flow of the IPTV channel switching

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### 3.2 Generating and Maintaining Channel List

- 1) Receives user’s IGMP request for channel starting.
- 2) Then IGMP snooping module will check the MAC frame from the IGMP message part, there are fields of new channel’s group address and the “JOIN” field for channel starting.
- 3) gets the “group address” for the channel.
- 4) checks PHY data with the “group address” for LLID.

Then the first two fields of channel list have been generated as table 1 below:

Table 1. Channel List

Multicast Group Address	LLID
225.1.1.21	24
225.1.1.22	56
225.1.1.23	43

In case of authentication are needed. There are fields of authentication in the channel list.

- 1) Receives user’s authentication message for channel starting.
- 2) analyzing the authentication message.
- 3) gets the authentication info.

Then the two fields of channel list authentication can be generated as table 2 below:

**Table 2.** Channel List

Multicast Group Address	LLID	Permission	ISP
225.1.1.21	24	Yes	X
225.1.1.22	36	Yes	Y
225.1.1.23	43	No	Z

The channels in EPON system usually changed dynamically according to end user's watching status. So the channel list should be updated dynamically or timely when the channel status changed.

### 3.3 Layered Implementations in ONU and OLT

This method can be implemented in OLT side or ONU side independently. Or it can be implemented in ONU and OLT at the same time as a kind of layered structure. For different implementation ways, the benefits are different.

When it is implemented in ONU only, it is an efficient implementation way, because ONU is the nearest node to end user. Thus it can make quicker response to its end user.

When it is implemented in OLT only, it is a secure way, because the OLT is located in carrier side and are managed by carriers, not by end user. And The OLT can have a channel list made by all the ONU it connected, the OLT can have larger channel list than ONU.

### 3.4 Message Sequences for Two Channel Switching Cases

There are two cases for end user about channel switching. One is to start a new channel when the TV is opened. The other is change a channel during watching a TV channel.

#### 1) Start a new channel A

As shown in figure 4, it is the sequence of this method for end user to start a channel. The ONU uses the channel list method to control the channel list. User A sends F1 to Multicast sever to start for channel A. User A sends F2 to authentication server to start for channel A. User A sends F3 to IPTV server to start for channel A. The ONU catches F1 and checks the channel list. Then it updates the LLID filter for the new channel A. The end user receives data of channel A. Then before the end user receives "ACK" messages "F4", "F5", "F6", the channel starting has been finished. It saved time.

#### 2) Switch to channel B from A

The ONU use the channel list method to control the channel list. User A is now watching Channel A. Then User A sends F1 to Multicast sever to switch to channel B. User A sends F2 to authentication server to switch to channel B. User A sends F3 to IPTV server to switch to channel B. The ONU finds F1 and checks the channel list. Then it updates the LLID filter for the new channel B. The end user receives data of channel B. Then before the end user receives "ACK" messages "F4", "F5", "F6", the channel switching has been finished. Then it saved time.

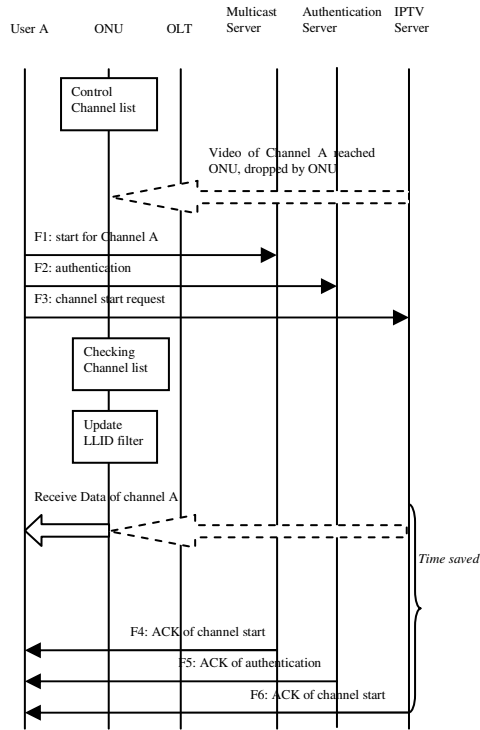


Fig. 4. Start a new channel

### 4 Test Bed

We implemented this method in a network structure as shown in figure 5 below. We tested the impacts about the channel switching method.

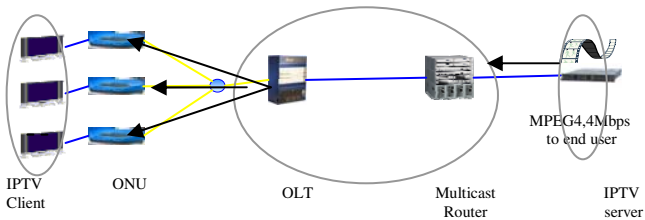


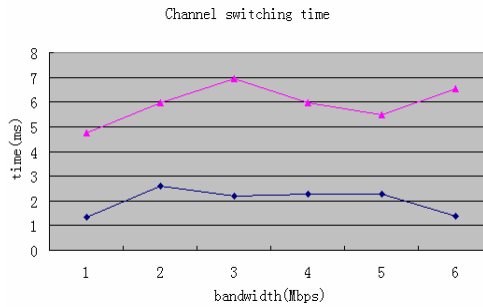
Fig. 5. Test bed

In figure 5, the method is implemented inside IPTV client. The IPTV server sends IPTV videos to 3 IPTV clients. In order to compare, IPTV client 1 has function of fast channel switching. IPTV Client 2 and IPTV Client 3 do not have the function of fast channel switching.

After testing the channel switching of three IPTV clients, we found the total time for channel switching are obviously different. IPTV client 1 that has the fast channel switching method has the shortest channel switching time.

To find out our method's benefit for IGMP message in channel switching time, we also test the system numerically. We measured the channel switching time in end user side especially for IGMP message.

When the end user made channel switching, IGMP 'JOIN' message will be sent from the end user's terminal to the network. We record the starting time from the IGMP 'JOIN' message. The end time is from the first coming UDP multicast packet of the new channel.



**Fig. 6.** Test result. The under blue line is result of the end user with the fast channel switching method. The upper pink line is the result of the end user without the fast channel switching method. For impact of IGMP delay, this presented method has a strong advantage.

It is critical to select the test tools and methodologies with the ability to test IPTV in the larger context of triple play networks to verify IPTV QoE under increasing scale, dynamic subscriber behavior, and amidst other voice and data services. Since quality can be inconsistent across the subscriber base, it's important to evaluate IPTV QoE on a per-subscriber basis. Our test is on such kind of structure to measure the behavior of subscriber.

## 5 Conclusion

In this paper, a fast channel switching method in EPON system for IPTV service is presented. Mathematical analysis for factors that impact channel switching time is discussed. The test system and test result show this method has strong impact on processing IGMP message. So that it can provide fast channel switching solution in EPON system.

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