Improving QoE in multicast IPTV systems: Channel zapping times

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The usage of Internet Protocol TV (IPTV) deployments in the consumer electronics market is growing very popular in recent years. In IPTV multicast systems, quality of experience is a very critical factor for user satisfaction. Existing and future IPTV systems will offer a large number of channels to users. The most important factors that affect the quality of experience in IPTV systems are channel zapping times. Generally, the channel zapping time depends on several parameters like IGMP command process time, network delay time, IPTV consumer device processing delay time, jitter buffer delay time, MPEG decoder time and conditional access/digital rights management (CA/DRM) delay time. In this paper, we presented an analysis of channel zapping time in IPTV systems and we proposed a new approach based on channel-based peer selection, called CBPS where the peer partner to construct peer-to-peer communication is discovered and unicast stream for joined channel will be get from peer partner during zapping process. By this way, black screen will not be displayed to user during zapping process until the channel stream coming from server is available. The simulation results in OPNET Modeler have been provided to demonstrate the performance of the proposed algorithm.

Key words: Internet protocol TV, channel zapping times, peer-to-peer transmission, quality of experience.

INTRODUCTION

Internet Protocol TV (IPTV) deployments become very popular with its advantages in the consumer electronics market in recent years. IPTV is a new form of digital television technology. In this system, digital television services are delivered to consumers over a network infrastructure by using internet protocol. IPTV is defined as multimedia services such as television/ video/ audio/ text/ graphics/ data delivered over IP based networks managed to provide the required level of quality of service and experience, security, interactivity and reliability (International Telecommunication Union Focus Group on IPTV, 2008). IPTV system uses the digital video compression techniques to transport the multimedia content to end-users.

Quality of experience (QoE) is the most important factor to satisfy the IPTV customers. Quality of experience is defined as the overall acceptability of an application or service as perceived subjectively by the end-user (International Telecommunication Union Focus Group on IPTV, 2007). Customers want to switch the IPTV channels very quickly and watch them to be smooth, non-blocking and without any interruption. From this perspective, quality of experience is the most important parameter for IPTV service providers to fulfill. Channel zapping time is considered as key element for quality of experience metric of multicast based IPTV systems (Hyunchul et al., 2008). Channel zapping time can be defined as the time difference between the currently watched channel and the display of the first frame of the new requested channel by end-user on the TV screen. So hence, the quick and reliable channel zapping time is the most important factor...
in validating quality of experience in multicast based IPTV systems.

There are various methods developed for improving channel zapping times (Hyunchul et al., 2008; Chunglae et al., 2004; Siebert et al., 2009; Chae et al., 2010; Zhang et al., 2009; Banodkar et al., 2008). Among the proposed methods in the previous works that we examined, many techniques from using multiple unicast streams to adding adjacent channels (Chunglae et al., 2004), using small group of pictures (GoP) size (Siebert et al., 2009), reducing IGMP command processing delay and predictive tuning via user's channel selection behaviors (Chae et al., 2010) were presented.

In this study, we proposed channel-based peer selection (CBPS) algorithm between peers in the IPTV multicast based system to reduce channel zapping times. When the zapping process is started by end-user, if the new tuned channel is not available in home gateway (HG), the peer partner among all peers viewing the new requested channel in the IPTV multicast group is discovered by executing channel-based peer selection algorithm and peer to peer fast communication is established between channel switched IPTV consumer device and it's peer partner to receive the new tuned channel. The information about the peer partner that constructs a peer to peer communication with channel zapped device is kept in a look-up table in IPTV central server. When a device starts channel zapping process, it gathers its best partner information from server. Thus, the time needed for IGMP command process and buffering for the new channel is removed. During zapping time, end-user will watch the channel from its peer partner.

Thus, the channel zapping time was decreased by half of the measured value in normal condition by our proposed algorithm.

This paper is organized as follows: Subsequently, it introduces typical channel zapping process in multicast IPTV systems, there after the parameters contributing to channel zapping delay are presented; then the proposed method is presented and simulation results in OPNET Modeler 14.5 (OPNET, 2011) are described; finally conclusion is presented.

CHANNEL ZAPPING PROCESS

In the traditional broadcasting services such as satellite, cable or terrestrial, TV or digital set-top-box can immediately display the selected channels when the user changes the watching channel because of all channels are transmitted at the same time to end-users. However, in IPTV systems, all channels can’t be transmitted to IPTV customers due to the lack of network bandwidth. The increase in usage of various multimedia services such as video-on-demand (VoD), pay-per-view (PPV) and other unicast video services will increase the bandwidth demand in network. Therefore, the bandwidth of the channels must be managed effectively because of each channel needs high-bandwidth (Hyunchul et al., 2008).

Some IPTV channels are available at the IPTV consumer device but when the user selects the unavailable channel at the IPTV consumer device, the channel zapping time will be very large compared to the channel zapping delays in the traditional broadcasting services. So hence, the channel zapping time is considered to be one of the most important qualities of experience metric in multicast-based IPTV systems. Figure 1 shows typical channel change process from the currently viewed channel (CH1) to newly tuned channel (CH2) in multicast based IPTV systems.

It was assumed that a TV viewer watches CH1 (channel1) and wants to change the current channel to CH2 (channel2) by pressing the keys (channel up / down, numerical, electronic program guide, favorite list etc.) on remote control/keypad of IPTV consumer device. At this moment, firstly, IPTV consumer device sends IGMP leave message for CH1 to home gateway.

As soon as home gateway receives IGMP leave message, an IGMP Group-Specific Query message is sent to home network and waits to get any response for CH1 from the local members in the group until the group specific query message’s maximum response time. If no reports are received from CH1, home gateway stops the forwarding of the multicast group for CH1 by sending an IGMP leave message to upper level router for the group. After IP-TV consumer device sends IGMP leave message for the current channel, it sends an IGMP join message for CH2 to home gateway. When home gateway receives IGMP join message, if there is no other local hosts that have membership for the group, it sends IGMP join message to upper-level router. When Last Hop Router (LHR) receives the join message, it sends a Protocol Independent Multicast (PIM) Join message to the other multicast routers in the access network. And then the requested multicast stream can be transmitted through several routers and home gateway to the IPTV consumer device (Chunglae et al., 2004).

Parameters for channel zapping latency

In general, the channel change time depends on several parameters in IPTV systems. The calculated delay times during channel change were provided in Table 1 (Begic et al., 2008). These parameters contributing to channel change delay are as follows:

Multicast leave and join command processing times

IGMP Command processing time is the time interval
between the remote control action and the transmission of the join message.

**Access network delay**

Network delay time is the time interval between the transmission of the join message and the reception of the first multicast packet of the requested channel.

**Jitter buffer delay**

IPTV consumer device jitter buffer delay time is the time until IPTV consumer device jitter buffer reaches the fullness set point prior to the forwarding of the video signal to the decoder function.

**Video decoding delay**

Video decoder delay time is the time interval associated to the video decoding process.

**CA/DRM system delay**

CA/DRM system delay is the time to read the necessary keys for CA/DRM and start descrambling the scrambled channel (Siebert et al., 2009). If the channels are free channels in IPTV multicast network, the descrambling process will not be needed. So this factor will not be affected the channel zapping times between free channels.

**Device processing time**

IPTV consumer device processing time is the time needed by IP stack of IPTV consumer device to process incoming packets and deliver the content to the MPEG decoder engine (Siebert et al., 2009).

**IR (Infra red) remote control delay time**

IR protocol and remote control delay time is the time
needed by processing IR remote control protocol keys that are sent by remote control.

MATERIALS AND METHODS

Here, we propose peer-to-peer communication between the channel zapping IPTV device and the other peer that will be discovered by using channel-based peer selection algorithm on IPTV network to overcome the problem of IGMP command processing delay during the channel zapping period in multicast-based IPTV systems. To select the peer partner, a look-up table on the IPTV server will be kept and updated regularly. Then this information will be sent to the channel zapped IPTV device at the zapping mode. When it receives the information related to its peer partner that views the requested channel and is in the nearest hop count away, the peer-to-peer communication will be started between channels zapped device and its peer partner. During zapping process, it will get unicast stream from its peer partner. By this method, the needed time to process IGMP command will be removed and so the zapping time will be decreased from 5 s to around 2 or 3 s. The proposed model to reduce channel zapping times was illustrated in Figure 2. In this figure, L1, L2, L3, L4, L5 shows the distance as a hops count between peer-to-peer nodes.

Peer selection algorithms are classified into two categories as user algorithms and global algorithms. The algorithms in the first group will be placed in receiver side and will run on each peer in the IPTV multicast group or peer-to-peer systems. The algorithms in the second group will run in centralized server and the peer selection control will be on server. In our approach, we will use channel-based peer selection algorithm running on IPTV central server. In this method, the channel information on the viewing mode and hops count information for all peers in the IPTV network will be collected in the look-up table as known Dynamic Hash Table (DHT) on the IPTV server. The information about the mode of peers (viewing/zapping/standby mode), the currently watched channel by the peers in the IPTV network and hops count between nodes will be included in the table and it will be updated regularly.

During channel zapping process in IPTV systems, it is assumed that TV viewer currently tune the CH1 at XXX.XXX.XXX.6 IP multicast address and requests to switch the CH2 at the XXX.XXX.XXX.9 IP multicast address. In this case, IPTV device firstly will send an IGMP Leave message and then IGMP Join message for new requested channel to HG. If the new requested channel to tune is not available in HG, the message including the information about some peers that views currently a new zapping channel will be sent to channel zapped IPTV device. In the look-up table on the server, it will be kept the distance information as a hops count for all peers with the channel information.

As soon as the channel switched IPTV device receives this message including the information about the peer that views currently the requested channel and also its distance (for example, 2 or 3 hops away) between the peer partner and the channel zapped user, it will try to connect its peer partner in the new IP multicast group to construct peer-to-peer communication with it during zapping process. While zapping mode, the channel zapped IPTV device will receive unicast stream from its peer partner by using the established IP unicast channel communication. Until the data for the zapped channel to tune from native IP multicast arrives and is buffered well to play, the unicast stream will be received from peer partner. When the channel coming IPTV multicast server is
available, IPTV consumer device will start to display it. By using unicast stream for new joined channel from peer partner, the stream of the new channel coming from peer partner will be available very quickly on IPTV device in zapping mode. The flow diagram for proposed model is shown in Figure 3.

In this way, the problem of IGMP command processing delay during channel zapping process will remove and so hence channel zapping delay in IPTV multicast systems will be reduced.

RESULTS

Here, simulation results were provided to demonstrate the performance of the proposed algorithm. For simulations, OPNET Modeler 14.5 network simulator was used. OPNET is an object-oriented simulator program that allows for modeling, simulating and analyzing the performance of communication networks. Figure 4 shows OPNET network model illustrating multicast IPTV network.

We created two multicast group, two routers illustrating FHR and LHR, IP network. We also created an IPTV head-end server to communicate with the multicast groups. A rendezvous point was defined on the routers routing multicast traffic between sender and receivers in the network.

Multicast tree was configured in the network. IP multicast traffic flow was created from IPTV head-end server to host nodes that is included in multicast groups. Figure 4 showed the basic topology that is used for our simulation. In our network model, the address of first multicast group was defined as 224.0.6.1 and the second multicast group address was defined as 224.0.6.2.

The definitions of multicast group address in OPNET modeler were presented in Figure 6. In Figure 4, the
In this paper, we discuss channel-based peer selection (CBPS) model to improve channel zapping times in multicast IPTV systems. In general, the channel zapping times take around 4 or 5 s or more in a IPTV multicast-based system. These times will not be acceptable for end-users. To ensure satisfactory QoE and guarantee the recommended MOS score (Rajah et al., 2008), these times needs to be below 2 s.

It is hard to test in the real IPTV network with head-end system because of complex security problems. To build IP multicast network and analysis the results, OPNET Modeler network simulator has been used. The simulation model for IP multicast network has been implemented to demonstrate how our proposed algorithm improves the performance of channel zapping time in IP multicast-based system.

During the simulation, two different scenarios have been developed. The comparison results concerning scenario1 and scenario2 were presented in Figure 7. During the simulation we got the number of average channel changing time as 0.67 s in normal state served by IPTV head-end server. With our proposed algorithm, the average channel zapping time decreased to 0.34 s. This simulation results showed that we can decrease the channel zapping time by half via our proposed algorithm.

Conclusion

In IPTV multicast systems, channel zapping delay or channel zapping time is the most important key factor of quality of experience. To satisfy the IPTV end user, reducing channel zapping delay is the most critical problem that is needed to solve by IPTV service providers. Channel zapping delay for IPTV multicast services should be as short as channel zapping times in traditional broadcasting services such as cable, terrestrial and satellite.

In this paper, firstly we investigated the channel zapping process and the channel zapping times in IPTV multicast systems. We presented the factors contributing channel zapping delay. Then we proposed peer-to-peer (P2P) communication by discovering of peer partner using channel-based peer selection algorithm that is running in the IPTV head-end server to remove IGMP command delay during channel zapping process and so reduce channel zapping delay. Experiment results show that CBPS algorithm can provide significant performance.

Figure 5. Best partner peer selection.
In this work, one network topology including video conferencing application for multicast sessions was considered. For future work, multicast network topology including live broadcast streams and scrambled streams will be considered during channel zapping process.

REFERENCES


