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IPTV Channel Zap Time Analysis

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Introduction

Nowadays in the telecommunications marketplace cable TV and telephone operators are deploying converged networks that can deliver data, voice, and video services to rapidly expanding customer base. Such networks are referred as Triple Play networks. The effective delivery of the video component of Triple Play services are called IPTV. IPTV is defined as multimedia services delivered over IP based networks able to provide the required level of quality of service and experience, security, interactivity and reliability [1–3].

IPTV - Internet Protocol Television uses multicast for transmitting and main problem is that all the channels cannot be transmited at the same time due to the lack of network bandwidth between last hop router and home gateway. Therefore, only a part of channels is immediately available at STB and delay is inevitable when user selectes new channel. The channel change time is called channel zap time.

A channel zap time is considered to be one of the most important parameter of quality of experience (QoE) metric in IPTV service. A channel change delay is defined as the time difference between time instance of request to change channel activated by pressing some buttons on the remote control and the time of display of the first frame of the requested channel on the TV screen. Unlike analog TV, channel zapping delay increases due to the necessity of audio/video data buffering, decoding at STB and other additional signaling information. Therefore the task is to minimize channel zap time. In this paper the modified channel change transmission algorithm is presented and IPTV channel zap time using the proposed algorithm and conventional IP multicast is compared.

Channel Zap Time

QoS (Quality of Service) is very important requirement for IPTV as it is a real-time service. QoE is defined as the overall acceptability of an application or service, perceived subjectively by the end-user. Channel zap time is one of the hot issues in IPTV QoE performance because it is directly related with subscribers and service providers. According to the test results from Agilent Technologies, the multicast operation time for 1000 users varies from 0.9 seconds to 70 seconds when changing channels. To ensure interactivity and satisfactory QoE, the channel zapping delay needs to be below 2 seconds, and to guarantee the recommended MOS (Mean Opinion Score) mapping [6]. Many research efforts have been devoted to find out how to reduce the channel zap time.

Generally, the channel zap time consists of command processing time, network delay, STB jitter buffer delay, and video decoding delay [4]. Components that contribute to channel zap time is present in Fig. 1.

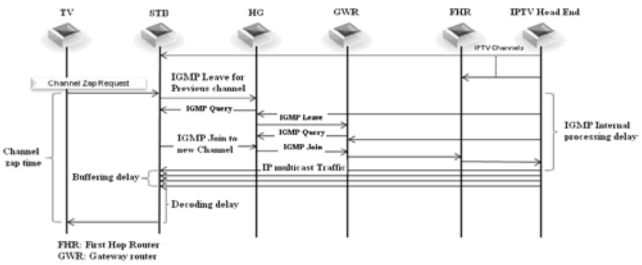

Fig. 1. Overall Channel Zapping Process [5]

Command processing time is the delay between time instance when the user process to select a new channel and the time instance when the IGMP Join message was transmitted into the network and processes. Network delay is the time needed to arrive of the requested stream after the transmission of the IGMP Join message. STB jitter buffer delay is required to remove the unsmooth display caused by the delay jitter over the Internet, and video decoding delay is caused by the fact that compressed video cannot be decoded without *I*-frames. Video decoding delay is related to the encoding structure, and the maximum video decoding delay is the length of a Group of picture (GoP) [4]. A channel zap request is triggered by a channel change which is mapped by the STB to a multicast group address carried in the IGMP message.

Modified channel change algorithm

The main idea of modified channel change algorithm is that, when user changes the channel and look at it less then 1 minute (T_v), the less quality video (MPEG-2, SDTV) from aggregated node is send to user. After 1 minute begins the transmission of high quality video. The flow chart of channel change using multicast transmission and proposed transmission method are present in Fig. 2.

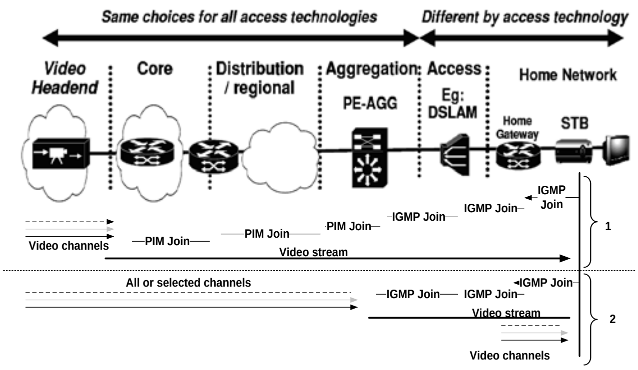

Fig. 2. Channel change using multicast channel flow (1) and proposed transmission method (2) in IPTV Network

The channel change using proposed transmission method algorithm is presented in Fig. 3.

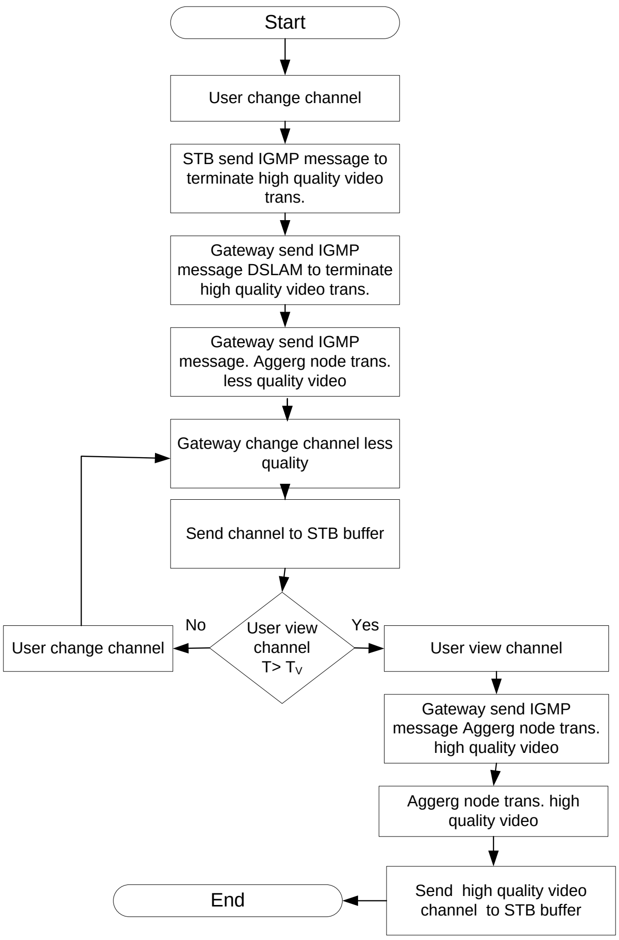

Fig. 3. The channel change algorithm of proposed transmission method

Mathematical model for evaluation of the channel zap time

The aggregation IPTV network structure is present in the Fig. 4. For evaluation of the channel zap time the flow was divided into the two segments: inter-stream and intra-stream. Intra-stream channel zapping needs only a command processing interval to change play pointer from aggregate node to user using less quality video. Inter-stream channel zapping is conventional multicast method.

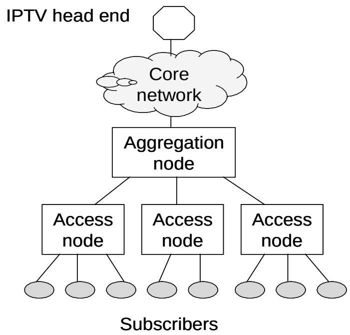

Fig. 4. Aggregated IPTV network structure

For evaluation of channel zap time, two probabilities were set [7]: P_0 is the probability of the inter-stream channel zapping; P_1 is the probability of the intra-stream channel zapping. The channel zap time is

$$D_{zapping} = P_0 \cdot D_{send} + P_1 \cdot D_{agg} + D_{b-jitter}, \qquad (1)$$

where D_{send} is the total channel change delay using conventional transmission; D_{agg} is the aggregated channel change delay; $D_{b\text{-}jitter}$ is the dejitter buffer delay.

The total channel change delay using conventional transmission can be evaluated as shown in (2)

$$D_{send} = D_{transm} + D_{switch} + D_{IGMP} + D_{DSLAM}, \qquad (2)$$

where D_{transm} is the transmission delay; D_{switch} is the switching delay; D_{IGMP} is the IGMP message transmission delay; D_{DSLAM} is the delay in the DSLAM.

The aggregated channel change delay can be expressed as

$$D_{agg} = D_{buff} + D_{signal} + D_{GOP}, \qquad (3)$$

where D_{buff} is the delay in the STB buffer; D_{signal} is the IGMP signalling transmission delay; D_{GOP} is the GoP delay.

IGMP signalling [8] transmission delay can be evaluated as shown in (4)

$$D_{signal} = \frac{M_{IGMP} \cdot N_{AN} \cdot N_{a-user}}{L_{rate} \cdot u \cdot B_r} + \frac{M_{IGMP} \cdot N_{AN} \cdot N_{a-user}}{L_{rate} \cdot d \cdot B_r}, \qquad (4)$$

where M_{IGMP} is the size of an IGMP packet; L_{rate} is the upstream and downstream line rate of core network; u,d are the traffic load rates of the up and down IGMP message; B_y is the real bandwidth ratio used by IGMP message packet; N_{AN} is the number of access nodes; $N_{a\text{-}user}$ is the number of active users.

The delay in the STB buffer is

$$D_{buff} = \frac{\dfrac{H_{r1} \cdot H_{r2} \cdot C_I \cdot F_I}{H_{comp}} \cdot N_{GOP}}{L_{RA} \cdot (1 - \rho_{other}) \cdot (1 - R_{IPTV})}, \qquad (5)$$

where H_{r1}, H_{r2} are the horizontal and the vertical video resolution, C_I is the colour image intensity; F_I is the frame intensity; H_{comp} is the video compression rate; N_{GOP} is the number of GoP; L_{RA} is the line rate between access and aggregation node; ρ_{other} is the traffic load of other services; R_{IPTV} is the ratio used for IPTV streaming.

The ratio used for IPTV streaming can be expressed as

$$R_{IPTV} = \frac{B_{MPEG} \cdot N_{ch} \cdot N_{ch-user}}{L_{RA} - (L_{RA} \cdot \rho_{other})}, \qquad (6)$$

where B_{MPEG} is the video MPEG bandwidth; N_{ch} is the number of channel; $N_{ch\text{-}user}$ is the number of users, which are using the same channel at the same time.

IPTV channel zap time comparison using the proposed algorithm and conventional IP multicast

The proposed algorithm was used to evaluate the channel zap time. For evaluation of the efficiency of proposed algorithm comparison with conventional IP multicast method was performed. The initial data used in the modeling are given in Table 1. The parameters for simulation are chosen on the basis of statistic from Cisco and Agilent Technologies. The standard TV (SDTV) MPEG-2 video resolution is 920x782, the high TV (HDTV) MPEG-4 - 1080x1920.

Table 1. The parameters used in simulation of zap time

Parameter	Value
$D_{b\text{-}jitter}$	150ms
D_{transm}	80ms
D_{switch}	2ms
D_{IGMP}	20ms
D_{DSLAM}	50ms
L_{RA}	100Mb/s
L_{rate}	1Gb/s
u,d	0.01
M_{IGMP}	64bit
N_{AN}	3
$N_{a\text{-}user}$	50
H_{r1}, H_{r2}	920x782
C_I, F_I, H_{comp}	8, 30, 30

The channel zap time value is influenced by many parameters. For this reason probability P_0, GoP size, user number were varied in some ranges and their influence to the channel zap time was analysed. Because in the network the other services are used, not only IPTV, during simulation the load of other service ρ_{other} was varied also. At first the influence of probability P_0 was investigated and obtained results are presented in Fig. 6 and Fig. 7. As can be seen the proposed algorithm enable to reduce the zap time up 1s, even in the case of other services load up to 0.5 of total throughput. Reduction of the GoP value by half, decreases the channel zap time by 0.6 times and the load of other service may be up 0.6 of total throughput. In the next step simulation, was carries out at number of active users $N_{ch\text{-}user}$, P_1=0.63

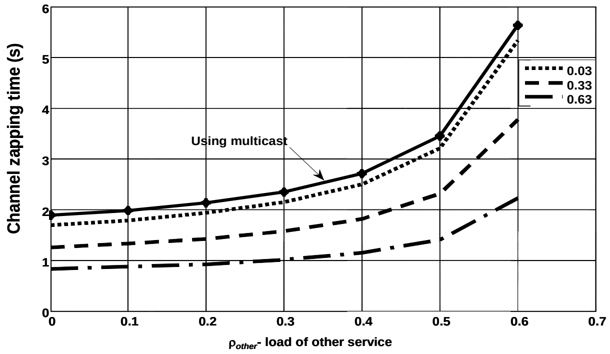

Fig. 6 Channel zapping time versus load of other services in the case of different IPTV intra stream probabilities (0.03; 0.33; 0.63), GoP=900ms

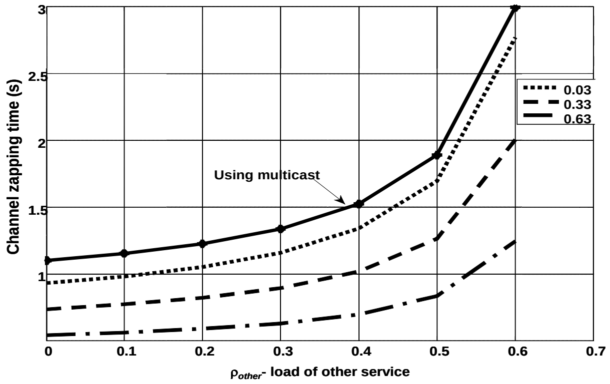

Fig. 7 Channel zapping time versus load of other services in the case of different IPTV intra stream probabilities (0.03; 0.33; 0.63), GoP=450ms

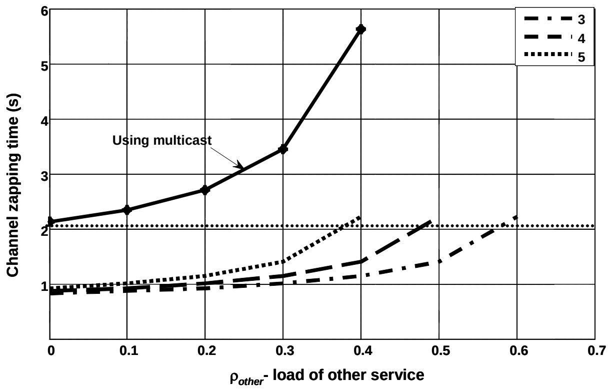

Fig. 8. Channel zapping time versus load of other services in the caseof different number of users ($N_{ch\text{-}user}$ =3; 4; 6), GoP=900ms

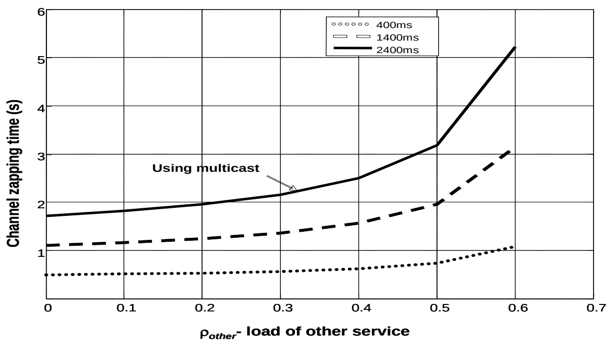

Fig. 9. Channel zapping time versus load of other services in the case of different size of GoP (400; 1400; 2400)

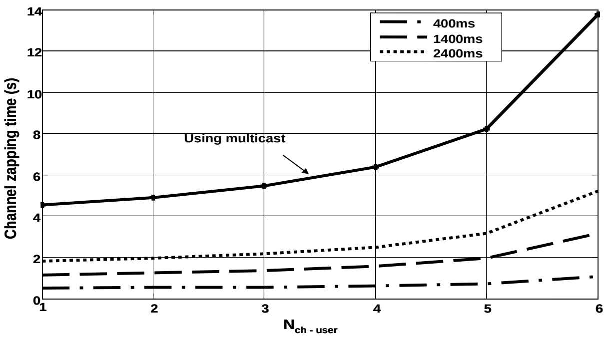

Fig. 10 Channel zapping time versus number of active users in the case of different size of GoP (400; 1400; 2400)

One of the important concepts behind MPEG encoding is the type of frame. There are three types of frames: *I*, *P*, *B* and all these are combined in GoP. Use of different GoP structure enables to controlle the channel zap time. Therefore analyses how GoP size influences the channel zap time is very important. The GoP size was chosen on the basis of statistic from Video research Library in Berlin.

Conclusions

This paper presents our modify channel change transmission algorithm and IPTV channel zap time comparison using the proposed algorithm and traditional IP multicast . Summering obtained results it can be state:

- using the proposed method, the channel zap time can be reduced by 60% and the load of other service may be up to 0.5 of total throughput;
- using small size of GoP channel zap time is ~ 1s, and the load of other services may be up to 0.6 by total throughput;
- the number of users, which change channel at the same time, very influences the zap time in the case GoP size is large and multicast is used. Using proposed method and the small size of GoP the channel zap time is decreased from 8 s down to 1,3 s. (5 users). Using large GoP size, channel zap time rapidly increases with increase of load of other services.

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This article analyzes one of the IPTV service quality indicators – channels zapping time. The propose a modified method of transmission channels change and mathematical model for IPTV network proposed. The main principle of proposed method is that, when user change the channel and look at it less then 1 minutes, less quality video (MPEG-2, SDTV) from aggregated node is send to user. After 1 minutes the transmission of high quality video starts. Using the proposed model the channel zapping time was analysed depending on the network and transferred image parameters. It was found that in the case of use of a modified algorithm, rather than a multicast transmission, channel switching time can be reduced up to 1.5 s. Ill. 10, bibl. 7, tabl. 1 (in English; abstracts in English and Lithuanian).

B. Dekeris, L. Narbutaitė. IPTV paslaugos kanalų perjungimo laiko analizė // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2010. – Nr. 10(106). – P. 117–120.

Straipsnyje analizuojamas vienas iš IPTV paslaugos kokybės rodiklių – kanalų perjungimo laikas. Sudarius modifikuotą vaizdo persiuntimo algoritmą bei sukūrus IPTV tinklo matematinį modelį, atliktas kanalų perjungimo laiko modeliavimas kintant tinklo bei perduodamo vaizdo parametrams. Sudaryto modifikuoto algoritmo esmė tokia: jei vartotojas kanalą žiūri mažiau nei 1 minutę, perduodamas prastesnės kokybės vaizdas, jei žiūri ilgiau, tuomet pradedamas transliuoti geresnės kokybės vaizdas. Nustatyta, kad naudojant modifikuotą vaizdo persiuntimo algoritmą, o ne daugiašalį perdavimo būdą, kanalo perjungimo trukmę galima sumažinti iki 1,5 s. Il. 10, bibl. 7, lent. 1 (anglų kalba; santraukos anglų ir lietuvių k.).