CHANNEL ZAPPING TIME ANALYSIS OF IPTV OVER WIMAX ACCESS NETWORK

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Abstract

IPTV – Internet protocol television - is a digital TV broadcast over IP networks, providing not only direct TV broadcasts, but also multiple additional services such as Video on Demand, an electronic program guide, internet service on the TV screen, games, karaoke and so on. IPTV and ancillary services conducted combining unicast and multicast flows in the methods of communication both core and access networks using different transmission methods, which are characterized by distinctive flows through the factors that influence the QoS. One of the most important factors for users evaluation of quality of service is a channel zapping time. Some of the factors that influence IPTV service channel zapping time is the delay in access and the user's home network nodes. In this paper we analyze the provision of IPTV over WiMax access network (IEEE 802.11d), the potential problems and the factors influencing the TV channel zapping time. A method to minimize the TV channel zapping time and simulated test environment results are presented and compared with the conventional transmission of IPTV over Wimax access network and proposed method of transmission over DSLAM access network.

1. Introduction

IPTV is defined as a multimedia service, with the necessary of using an IP core network and service providers chosen access network for TV channels transmission. Unlike the core network, the selection of IPTV access network is influenced by various factors, such as: geographic location of IPTV users, infrastructure of equipment deployment options in the access network, the economic benefits and in this case for IPTV service providers is especially important properly choose the right infrastructure of IPTV service access network.

WiMax (Worldwide Interoperability for Microwave Access) is a wireless access network, widely used for high data rate in a wide range of users coverage. Due to the wide range of users coverage, WiMax network provides access to the services in remote areas, where implementation of other access infrastructure (DSL, optic) is simply too expensive or altogether impossible. These basic characteristics affect service providers selection of WiMax network as an access network for IPTV and additional multimedia services. There are two principal WiMax network structures: fixed access WiMax network (IEEE 802.16d) and mobile access WiMax network (802.16e) [1]. In this paper authors analyze the impact of WiMax network (IEEE 802.16d) used as an IPTV access network to IPTV QoE (Quality of Experience) in respect of the users.

IPTV service providers undertake to ensure proper quality of service (QoS) in accordance with approved ITU-T recommenddations, ensuring TV users satisfaction with the service. Quality of Service (QoS) and service quality of experience (QoE) ratio is very important for the IPTV service, because each of these characteristics value affects the IPTV service core and access networks settings, such as [2]:

- Packet loss rate;
- Packet jitter;
- End to end delay;
- Channel zapping time.

IPTV traffic transmission rate over fixed Wimax access network varies from one to several Mbps and therefore transfer rate for service is limited. Due to the limited access network bandwidth, IPTV service equipment, such as STB (Set Top Box), can not simultaneously receive all broadcast channels and when the user selects of a new TV channel inevitably emerges channel change delay in the access network [3]. Method to minimize IPTV channel zapping time over fixed WiMax access network and simulation results are presented in this paper.

2. IPTV over fixed WiMax

IEEE 802.16d fixed wireless access network provides the opportunity to transfer both standard definition (SD) and high definition (HD) video streams, accordingly WiMax access network is used for IPTV service provision. Figure 1 shows the architecture of IPTV service over fixed WiMax access network.

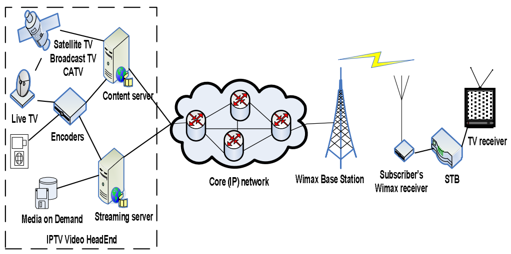

Figure 1. IPTV over fixed WiMax access network

IPTV service architecture over a fixed WiMax access network consists of Video HeadEnd, core (IP) network, access network (WiMax Base Station (BS), subscriber's WiMax receiver, STB (Set Top Box), TV receiver.

3. IPTV channel zapping time

IPTV channel zapping time is the time lag from the channel change request as the user pushes the button on the remote control untill the first video I frame is received on STB. Channel zapping time is an important QoE parameter for IPTV user, so in this case, according to the research work [4], channel zapping time should be less than 0.43 ms in order to ensure user satisfaction with the IPTV service by at least 3.5 points by MOS (Mean Opinion Score), so it is very important as far as possible to reduce it.

IPTV service channel changing process is presented in Figure 2. The channel zapping time is composed of these main factors:

- IGMP processing time – delay, resulting from the first IGMP Leave request on the STB to the Home Gateway untill the first I frame of the selected TV channel, received in the STB buffer;

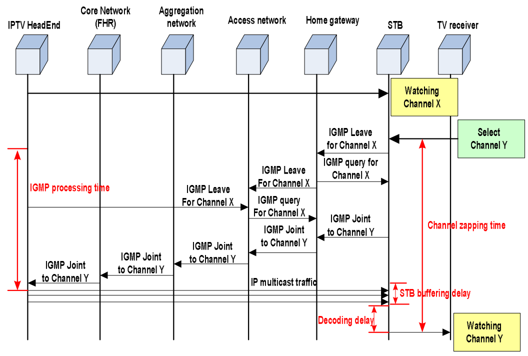

Figure 2. Overwiev of channel zapping time

- Access network delay – time, needed to broadcast video stream from the selected channel IGMP Join request submission;
- STB jitter buffer delay – is required to remove the unsmooth display caused by the delay jitter over the Internet [3];
- Video decoding delay – the time required for video stream decoding and presentation from the STB to the TV receiver. This time is influenced by the arrangement of images sequence (I, B, P) in the GOP (Group of Picture).

4. Proposed IPTV channel change method

To compare the results obtained by simulation [3], authors proposed IPTV channel change method is adapted to the IEEE 802.16d WiMax access network (Figure 3).

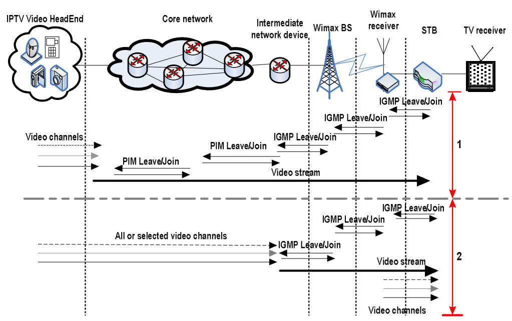

Figure 3. IPTV channel change using multicast channel flow (1) and proposed transmission method (2) using fixed WiMax access network

Figure 4 presents the IPTV service channel change algorithm using the authors proposed IPTV transmission method.

The main idea of the proposed channel change method is that, when the IPTV service user press the channel change button on the remote control and looks forward during switching process less than 1 minute (T_V), the intermediate network device starts send less quality (MPEG - 2, SDTV) video stream of the selected channel. Less quality video stream is replaced by the high quality (HDTV) video stream only after 1 minute from the channel change request.

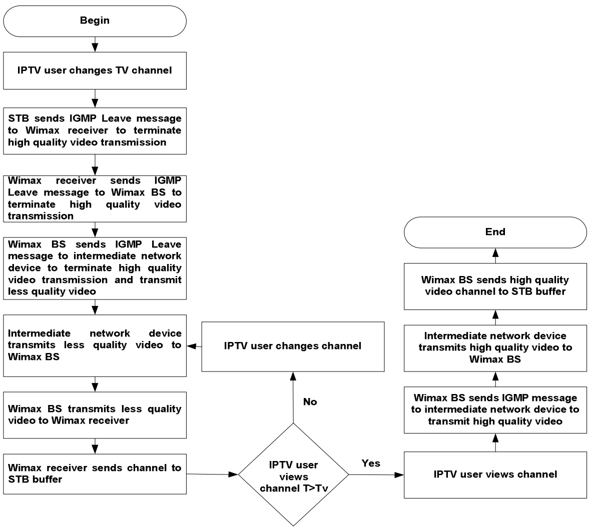

Figure 4. IPTV channel change algorithm of proposed transmission method

5. Mathematical model for IPTV channel zapping time evaluation over fixed Wimax access network

First of all, the IPTV channel zapping time evaluation over fixed WiMax access network has been done for two scheduling types of IPTV traffic: a non-priority and priority IPTV traffic. Figure 5 presents the schemes of two scheduling types of IPTV traffic.

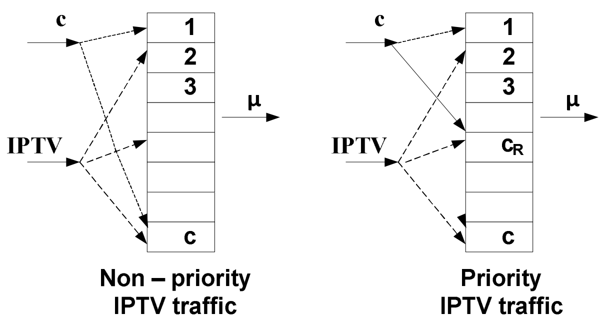

Figure 5. Schemes of two scheduling types of IPTV traffic: non - priority and priority

The non-priority scheme does not differentiate between common data traffic and IPTV traffic and all channels in BS are using for all types of services. Using priority scheme channels were divided into two parts: normal and reserved for IPTV. When a common call arrives, the system will check if there is an available normal channel for it. If it is not available, the call will be blocked. When IPTV call arrives, the system will check if there is an available normal channel for it. If it is available, a channel will be assigned for the call. If it is not available, the system will check if there is an available reserved channel for it. If it is available, a channel will be assigned for the call. If it is not available, the call will be blocked. For evaluation the IPTV traffic blocking probability Markov chain is used. Each state, in the Markov chain represents the number of occupied channels .The all traffics are assumed to follow a Poisson arrival process with mean rates λ_c – for total channels and λ_{IPTV} – for IPTV channels. They have exponential service time distribution with mean rate $\frac{1}{\mu}$. Here are a total of C channels of which $C_{IPTV}=C-C_R$ (where C_R – number of reserved channels) are prioritized only to IPTV traffic. Solving the Markov chain authors get IPTV traffic blocking probability:

- for non-priority scheme:

$$P_{IPTV}=\frac{\dfrac{(\lambda_c+\lambda_{IPTV})^C}{C!\cdot\mu^C}}{\sum\limits_{j=0}^{C}\dfrac{(\lambda_c+\lambda_{IPTV})^j}{j!\cdot\mu^j}}, \qquad (1)$$

- for priority scheme:

$$P_{IPTV}=\frac{(\lambda_c+\lambda_{IPTV})^{C_{IPTV}}\times(\lambda_{IPTV})^{C-C_{IPTV}}}{C!\cdot\mu^C}\times P(0), \qquad (2)$$

where P_{IPTV} – is IPTV traffic blocking probability; P(0) – probability, that all channels are available:

$$P(0)=\left[\sum_{j=0}^{C_{IPTV}}\frac{(\lambda_c+\lambda_{IPTV})^j}{j!\cdot\mu^j}+\sum_{j=C_{IPTV}+1}^{C}\frac{(\lambda_c+\lambda_{IPTV})^{C_{IPTV}}\times\lambda_{IPTV}^{\,j-C_{IPTV}}}{j!\cdot\mu^j}\right]^{-1}, \qquad (3)$$

The channel zapping time is

$$D_{zapping}=D_{send}+D_{buff}+D_{signal}+D_{GOP}+D_{b-jitter}+D_{retrans}, \qquad (4)$$

where $D_{zapping}$ is the channel zapping time; D_{send} is the total channel change delay using conventional transmission; D_{buff} is the delay in STB buffer; D_{signal} is the IGMP signalling transmission delay; D_{GOP} is the GOP delay; $D_{b\text{-}jitter}$ is the dejitter buffer delay; $D_{retrans}$ is the retransmission delay. The total channel change delay, using conventional transmission can be expressed as

$$D_{send} = D_{transm} + D_{switch} + D_{IGMP}, \quad (5)$$

where D_{transm} is the transmission delay; D_{switch} is the switching delay; D_{IGMP} is the IGMP message transmission delay. The delay in STB buffer can be expressed as

$$D_{buff} = \frac{\frac{H_{r1} \times H_{r2} \times C_I \times F_I}{H_{comp}} \times N_{GOP}}{L_{BS} \times (1-\rho_{other}) \times (1-R_{IPTV})}, \quad (6)$$

where H_{r1}, H_{r2} are horizontal and 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_{BS} is the line rate of BS; ρ_{other} is the traffic load of other services. R_{IPTV} is ratio, used for IPTV streaming, which can be evaluated as

$$R_{IPTV} = \frac{B_{MPEG} \times N_{ch} \times N_{ch-user}}{L_{BS} - (L_{BS} \times \rho_{other})}, \quad (7)$$

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

The retransmission delay can be evaluated as

$$D_{retrans} = (D_{signal} \times P_{IPTV}) \times 10, \quad (8)$$

IGMP signalling transmission delay can be expressed as

$$D_{signal} = \frac{S_{IGMP} \times N_{ch-user}}{L_{rate\_down}} + \frac{S_{IGMP} \times N_{ch-user}}{L_{rate\_up}}, \quad (9)$$

where S_{IGMP} is the size of IGMP packet; L_{rate_down} is the downstream line rate of access network; L_{rate_up} is the upstream line rate of access network.

6. Results of IPTV channel zapping time over IEEE 802.16d access network using proposed transmission method

According to the mathematical model, the efficiency of the IPTV channel change algorithm of proposed transmission method was performed using a Matlab simulation program. The initial data, used in simulation, according to Cisco and Agilent Technologies, are given in Table 1.

The simulation was done by changing the GOP size (Figure 7), IPTV probability P (Figure 8) and as were used other services in the network, not only IPTV, the load of other services ρ_{other} was varied too. Figure 6 presents IPTV traffic blocking probability in BS with two scheduling types.

Table 1. Parameters used in simulation

Parameter	*Value*
$D_{b\text{-}jitter}$	150ms
D_{transm}	80ms
D_{switch}	2ms
D_{IGMP}	20ms
D_{DSLAM}	50ms
L_{BS}	250Mbps
L_{rate_up}	3Mbps
L_{rate_down}	10Mbps
S_{IGMP}	64bit
N_{ch}	3
$N_{ch\text{-}user}$	20
H_{r1}, H_{r2}	920x782
C_I , F_I ,H_{comp}	8, 30, 30
C	30
C_{IPTV}	5
B_{MPEG}	2Mbps

As can be seen, when is used the priority IPTV traffic, the probability that the call, that came will be blocked is far lower than in non-priority IPTV traffic. In this case, using a sheduling type of priority IPTV traffic in WiMax BS, IPTV applications will be attended with lower losses.

Comparing channel zapping time values of the proposed method of transmission over WiMAX access network to the IPTV transmission over DSLAM access network, when the GOP=1.6 s, channel zapping time increases by less than 0.6 s.

In contrast to the DSLAM, it is influenced by the retransmission delay over WiMax access network.

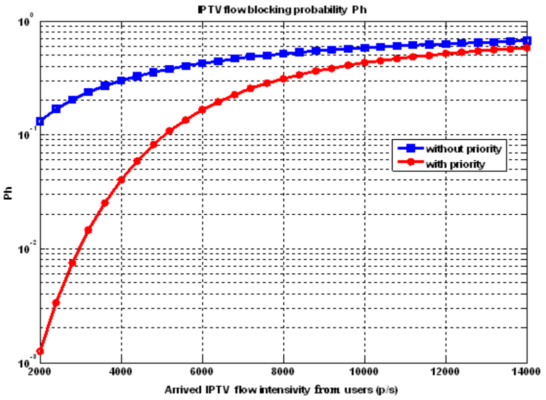

Figure 6. IPTV traffic blocking probability in BS with two scheduling types: with priority and without priority

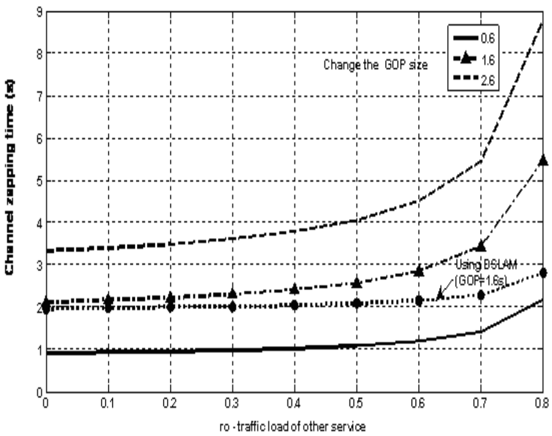

Figure 7. Channel zapping time versus load of other services, in the case of different GOP sizes (0,6 s; 1,6 s; 2,6 s)

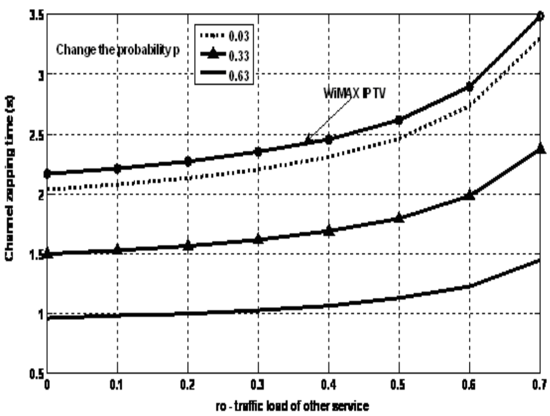

Figure 8. Channel zapping time versus load of other services in the case of different IPTV probabilities (0,03; 0,33; 0,63), GOP=1,6s

Comparing channel zapping time value of the traditional method of transmitting IPTV over WiMax to the proposed transmission method, when the GOP is equal to 1.6 s, it can be seen, that the proposed method can reduce the channel zapping time by more than 1.5 s, and the load of other services may be up to 0.6 of total throughput.

7. Conclusions

In this paper authors proposed IPTV channel change transmission algorithm and compared channel zapping time: a) using conventional transmission over WiMax access network and proposed method; b) using transmission of proposed method over WiMax access network and DSLAM access network. According to the obtained results, it can be stated:

- using a non-priority IPTV traffic in WiMax BS, IPTV applications will be attended with more losses than priority IPTV traffic;
- if GOP = 0.6 s, channel zapping time is about 1 s using the proposed method of transmission over WiMAX access network;
- Channel zapping time value (GOP = 1.6 s) of the proposed transmission method is 1.5 times lower than in conventional IPTV transmission over WiMax.

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