Influence of Users Behaviour to IPTV Service

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***Abstract*— TV channel transmission of interactive IPTV service and the channel zapping process are influenced by users searching and viewing behaviour. The model of users behaviour influence to IPTV service and reliance on IPTV channel transmission are presented. The users IPTV channel selection from offered number of TV channels was evaluated. Estimated dependence on quantity of IPTV users to IPTV transmission method and network bandwidth settings.**

***Index Terms*—Channel transmission, IPTV, QoE, user's behaviour.**

I. INTRODUCTION

Transmission of television (TV) using telecommunication networks, based on Internet Protocol (IP), gives an opportunity for service provider to satisfy the individual needs of each IPTV user. The main factors of the quality of experience (QoE) are defined in ITU-T G1080 recommendation. One of them is the IPTV channel change time (zapping). Many research efforts have been undertaken to reduce channel zapping time and some methods have been proposed [1]–[3]. One of them proposes to reduce some IGMP parameters or first *I* frame delay. In other works the pre-join for selecting the next channel are analysed. Based on the currently watched channel, and assuming that most users use the up/down button of their remote control to surf, adjacent channels can be joined in advance or sent by the IPTV head-end in low resolution. The IPTV subscribers forecasting, channels' popularity, personal channel preference, and behaviour in operating the remote control [4]–[7]. Predictive tuning consumes additional network resources for prejoining channels, which can cause congestion in the access network. Due to this reason it is important for service provider to analyze and evaluate behaviour of each user with respect to IPTV service. In order to save network capacity while at the same time reducing the channel zapping time, the IPTV network operator can choose transmission method: the multicast for the most popular channels while unicast for the other channels (HDTV, VoD).

The objective of this work is to proposed model which can be used to estimate the throughput for transmission of IPTV in the network with both multicast and unicast capabilities and to analyze influence of users' behaviour to IPTV channel transmission.

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II. MODEL OF USERS' BEHAVIOUR INFLUENCE ON IPTV SERVICE

The proposed model for evaluation of users behaviour influence on IPTV channel zapping process and capacity for transmission of TV channels is presented in Fig 1. IPTV service attraction to the users not only based on transmission of individually selected IPTV channel, but also on the channel search and selection possibilities. These possibilities are based on the recommendation mechanisms of IPTV users' behaviour evaluation [6], according various IPTV users' specific features, such as user activity, interests, mood, experience, geographic location, etc. Influence of users' behaviour on the IPTV service is evaluated by processing behavioural factors using methods of statistical analysis, as the users use IPTV service randomly and independently from one another. Using the proposed model the TV channel dynamical can be grouped into two categories: popular or unpopular.

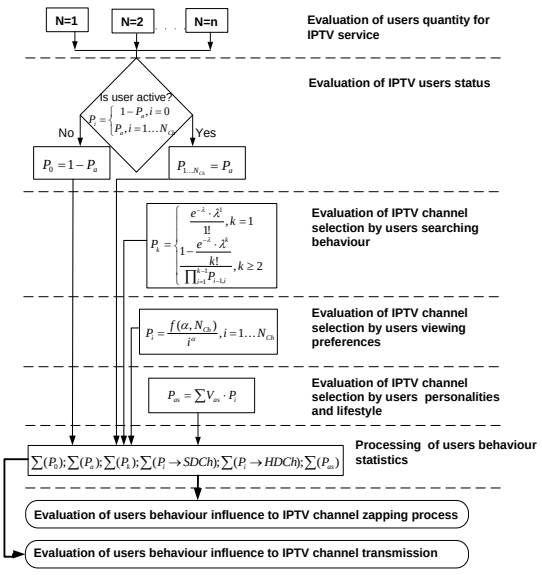

Fig. 1. Model of users behavior influence on IPTV service.

When the network operator has these results, he can choose the transmission method of TV channels and group users' STB into cluster. These results can be used for personalized electronic program guide too.

III. ANALYSIS OF THE IPTV VIEWING BEHAVIOR AND THROUGHPUT FOR TRANSMISSION OF TV CHANNELS

According to the proposed model, only a part of total number of IPTV users N will be active users N_a. IPTV

users' activity states are described by the probabilities $P^u(i)$ that can be calculated using following equation

$$P^u(i) = \begin{cases} P_a, & i \in \{1 \cdots N_{Ch}\}, \\ 1 - P_a, & i = 0, \end{cases} \quad (1)$$

where $P^u(0) = 1 - P_a$ is a probability of number of inactive IPTV users; P_a is a probability of number of active IPTV users; N_{Ch} is number of TV channels.

In order to generate the data of set, describing IPTV users, the function F_{Ch}, which defines popularity of IPTV channels, has been used [4]

$$F_{Ch} = \sum_{i=1}^{N_{Ch}} P_{Ch}(i), \quad (2)$$

where $P_{Ch}(i) = \frac{f(\alpha, N_{Ch})}{i^{\alpha}}$ is the probability, that IPTV channel by the popularity i will be selected; $i = [1 \ldots N_{Ch}]$ is the index of channel selection by the popularity; α is the *Zipf* law index, describing the form of the distribution law; f is the *Zipf* law rating constant, which ensures that the sum of all probabilities does not exceed 1; N_{Ch} is the number of TV channels. It was assumed that IPTV channels selection popularity between users is defined by *Zipf* distribution law.

In order to investigate the total number of viewing different IPTV channels statistical data is needed, therefore multiple tests have been carried out. During each of the tests the set of user status has been generated several random variables $y_{n,k} \sim f(0,1)$ and $x_{n,k} \sim f(0,1)$. The set of viewing IPTV channels of each user was generated by formulas [8]:

$$U(n,k) = \begin{cases} \sum_{i=1}^{N_{Ch}} K(y_{n,k}, i), & x_{n,k} < P_a \\ 0, & x_{n,k} \geq P_a, \end{cases} \quad (3)$$

$$K(y_{n,k}, i) = \begin{cases} 1, & F_{Ch}(i) \leq y_{n,k}, \\ 0, & F_{Ch}(i) > y_{n,k}, \end{cases} \quad (4)$$

where $k = [1 \ldots G]$ is the number of test from set G; $n = [1 \ldots N]$ is the user number from set N IPTV users; $K(y_{n,k}, i)$ is an additional function for index selection of viewing IPTV channel for each of the users.

The total number of viewing different IPTV channels of k^{th} tests was found using (5).

By using proposed model, behaviour of IPTV users has been analysed by generating total $G = 500$ tests. In the each of test, which was carried out, the number of IPTV users was $N = 1000$ and the total number of IPTV channels $N_{Ch} = 57$. The probability of the activity of each users was $P_a = 0.6$.

The total number of active users $N_a = 601$, which watch at least one IPTV channel, and the number of inactive users is 399. IPTV channel popularity distribution by the different form of the distribution law is presented in Fig. 2.

$$\begin{cases} N_{dTV_k} = \sum_{i=1}^{N_{Ch}} S_{dTV}(k,i), \\ S_{dTV}(k,i) = \begin{cases} 1, & S_k(i) > 0, \\ 0 & S_k(i) < 0, \end{cases} \\ S_k(i) = \sum_{n=1}^{N} U_{sk}(n,k,i), \\ U_{sk}(n,k,i) = \begin{cases} 1, & U(n,k) = i, \\ 0, & i = 0, \end{cases} \end{cases} \quad (5)$$

where $S_{dTV}(k,i)$ is the number of viewing different IPTV channels by users; $S_k(i)$ is the total number of users viewing i^{th} IPTV channel of k^{th} tests; $U_{sk}(n,k,i)$ is the set of IPTV users viewing i^{th} IPTV channel of k^{th} tests; N is the total number of IPTV users.

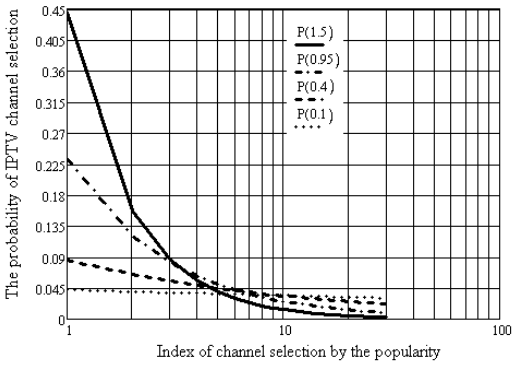

Fig. 2. The distribution of the probability of IPTV channel selection versus channel popularity in case of different the distribution law index α = 0.1; 0.4; 0.95; 1.5.

For higher index α of the distribution law, the probability $P(\alpha, i)$ is greater that the user selects one of 10 most watchable IPTV channels. For IPTV service provider it is important to determine the optimal number of TV channels offered. The influence of offered number of TV channel on probability of channel selection was investigated and obtained results are presented in Fig. 3 and Fig. 4.

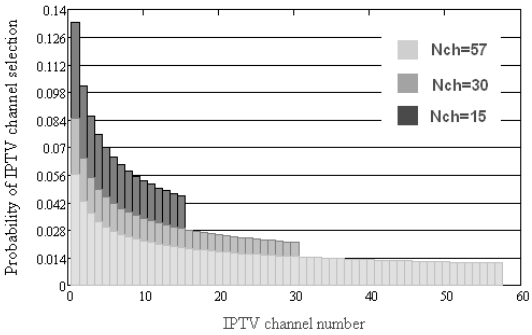

Fig. 3. The distribution of the probability of IPTV channel selection versus of IPTV channels number in case of different of offered IPTV channels N_{Ch}, $\alpha = 0.4$.

As can be seen, the optimal number of IPTV channels for individual user, accounting user behavior and channel popularity, is in the range from 10 to 15. It is very important for making the personalized electronic program guide. The dependence of watching different IPTV channels by active IPTV users versus total number of active users is presented in Fig. 5.

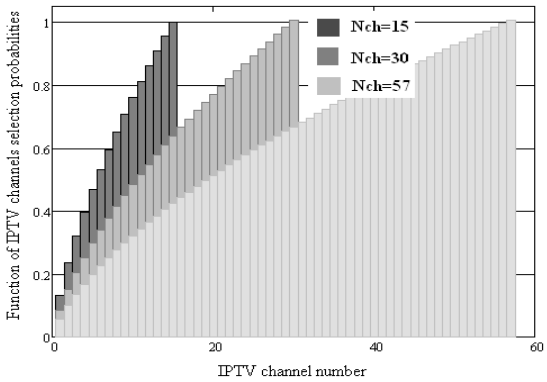

Fig. 4. The function of IPTV channels selection probabilities, versus of IPTV channels number in case of different of offered IPTV channels N_{Ch}, $\alpha = 0.4$.

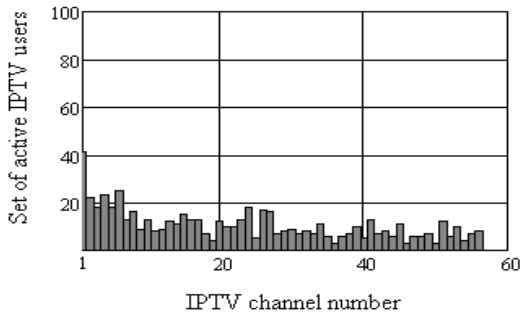

Fig. 5. The set of active IPTV users on watching different IPTV channels versus of IPTV channels number.

The next step after determination of the total number of active IPTV users N_a is investigation of total throughput for transmission, taking into account the number of active IPTV users and minimal requirement of the throughput C_{SD} for one SD (standard definition) and C_{HD} – HD (high definition). The investigation was carried out for two different types of streams for TV transmission: unicast and multicast. The expression of the throughput C_{uni} for SD channels transmission using unicast stream calculation is

$$C_{uni} = N_a \cdot C_{SD}. \quad (6)$$

The throughput C_{multi} for SD channels transmission using multicast stream can be calculated using

$$C_{multi} = N_{dTV} \cdot C_{SD}. \quad (7)$$

The throughput for both unicast and multicast transmission according to the channel popularity are given by

$$C = (N_{dTV} + S_{dTV}(k, i_{HD}) - 1) \cdot C_{SD} + \sum_{i=1}^{L} S_{k_i}(i_{HD}) \cdot C_{HD}. \quad (8)$$

Obtained results of throughput for channels transmission are presented in Table I.

TABLE II. THROUGHPUT FOR IPTV SERVICE TRANSMISSION (MBIT/S).

Scenarios	SD-unicast	SD multicast	2&HD-unicast, SD-multicast
Nch=57	1024	112	459
Nch=30	1232	60	677
Nch=15	1252	30	710

IV. EXPERIMENTAL EVALUATION OF NUMBER OF USERS AND VIEWING CHANNELS INFLUENCE ON IPTV CHANNELS THROUGHPUT UTILIZATION

The main idea of the experiment was to validate the proposed user behaviour model. The structure of experimental network is presented in Fig. 6. The network has 7 IPTV users, one switch and two routers with multicast function and one IPTV server. The set from 1 till 7 channels at once were used for broadcasting. The throughput of all links was 100 Mb/s. As the source of video various movies with different resolution have been used. The parameters of video sources that were used for experiment are presented in Table II.

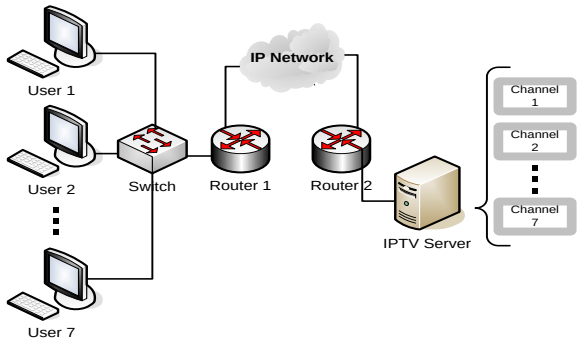

Fig. 6. The structure of experimental network.

TABLE II. PARAMETERS OF VIDEO SOURCES.

Channel No	Resolution	Frames/s	Codec
1	704x288	25	MPEG-4
2	656x368	25	MPEG-4
3	640x336	25	MPEG-4
4	704x288	29	MPEG-4
5	704x288	25	MPEG-4
6	656x368	25	MPEG-4
7	640x336	25	MPEG-4

The VLC media player was used for broadcasting and watching of IPTV channels in this experiment. Packets analyzer Wireshark was used for measurements througput of IPTV. The size of Ethernet frame with all necessary headers and video data was 1370 B.

The experiment was carried using two IPTV transmission methods: multicast and unicast. During the broadcasting of multicast stream, number of channels varied from 1 to 4 and number of users varied from 2 till 7. The results obtained are shown in Fig. 7–Fig. 9.

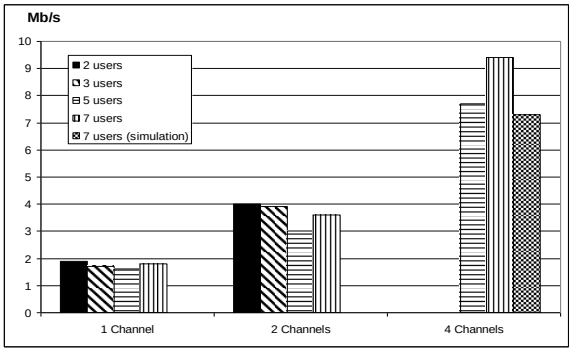

Fig. 7. Average data throughput versus number of channels and users using multicast transmission.

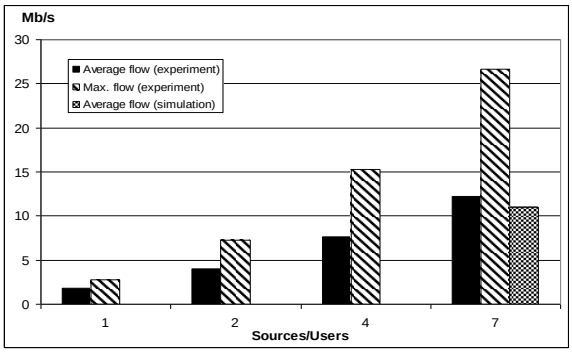

Fig. 8. Data throughput versus number of channels and users using unicast transmission.

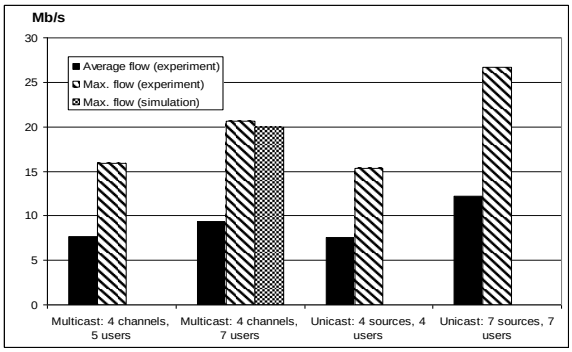

Fig. 9. Data flow of multicast versus unicast.

As can be seen, multicast stream data flow depends only from number of broadcasting IPTV channels. It was obtained that the required throughput for multicast is 9.4 Mb/s and unicast 12.2 Mb/s. This coincides with modelling results which give 7.3 Mb/s for multicast and 11 Mb/s for unicast. The similar coincidence was obtain in the case of transmitted 2 of 7 HDTV IPTV channels, when in the case of modelling the required throughput was obtained 20 Mb/s and experiment estimation is 27 Mb/s (Fig. 9).

V. CONCLUSIONS

As the result of carried out analysis for the model of influence of users' behaviour to IPTV service it can be stated that if IPTV user chooses TV channel by popularity, IPTV service provider can predict the user's viewing preferences, influencing not only the channel transmission, but the channel zapping process too. The throughput required for IPTV channel transmission and better utilization of channel can be reduced by using multicast traffic with large number of active IPTV users and unicast traffic (such as VoD or HDTV broadcasting) more targeted approach in use of a smaller number of active IPTV users.

Our future work will focus on investigating the proposed model of users' behaviour influence to IPTV service by factors for IPTV channel zapping process.

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