International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869, Volume-2, Issue-2, February 2014

Modified HLS Model for IPTV Streaming

S. Japertas, T. Baksys, T. Zelvys

Abstract— **Present basic IPTV streaming technologies (as plain Multicast) become too slow, static and don't satisfy users' requirements. To make streaming more mobile, there was tested Apple Inc. (Apple) HLS model. Regarding to the test results there was created a modified model, which has better characteristics of traffic shaping, bandwidth load balancing and mobility. Collecting user statistics and understanding their habits allowed creating an adaptive streaming way that could transfer data to users collectively without wasting the traffic. Every user is connected to a unicast-based cache server, which collects user requests and connects to the main HTTP server. Cache servers start downloading the information form HTTP server only on demand and only the information that is requested. The downloaded information is cached in the Cache servers' memory and can be shared among the parallel clients, limiting the traffic only to the one channel is broadcasted.**

Index Terms—**Digital multimedia broadcasting, IPTV, Unicast, Cache memory**

I. Introduction

Problems of telecommunication services development are experienced recently. The problems are caused by outdated communication technologies that require a large investment to be replaced, a homogeneous network structure and specific software solutions.

These trends especially occur in networks that are used for audiovisual data streaming, which traditionally uses the Multicast signal transmission technology. This information transfer technology greatly restricts data accessibility to the consumer by setting very high standards of service quality requirements, which obliges the audiovisual service provider to ensure very high network permeability. Along with increasing consumer needs, service providers are experiencing service accessibility, supply and large data flow problems, which are tried to being tackled by different companies.

The review of transfer technologies that were made by the IETF team (Internet Engineering Task Force) revealed that the HTTP Live Streaming (HLS) concept of audiovisual data transmission over IP networks. HLS describes the principles of continuous IPTV stream sampling and transfer by HTTP protocol implemented by company Apple is the most universal [1].

This work presents the solution which uses HLS stream sampling (segmentation) principle suggested by Apple that allows audiovisual data stream provision to the customers. This technology allows segmentation of multiple data flow and it can be provided to the users in Open Source format.

Manuscript received February 20, 2014.

Saulius Japertas, Telecommunications Department, Kaunas University of Technology, Kaunas, Lithuania, Mobile phone No +37068525830.

Tatutvydas Baksys, Telecommunications Department, Kaunas University of Technology, Kaunas, Lithuania, Mobile phone No +37061447065.

Tautvydas Zelvys, Department of Multimedia Engineering, Kaunas University of Technology, Kaunas, Lithuania, Mobile phone +37037300530

II. Standard Apple Model

The concept implemented by Apple is reflected in the block diagram Fig. 1. The main task of Apple HLS model is to discretize stream in real time and to transmit received information to the user by using HTTP(s) protocol. The flow of continuous stream in POSIX operation system is shown in 1 – 4 blocks. Multimedia streams are formed of audio-visual information that is transferred to the HLS server where it is buffered. In the software segmentator the stream is cut into to indexed files, which are transmitted to the servers' dynamic random access memory (RAM). RAM is used for short-term data storage when data recording and reading is performed at a high speed.

It is very important to ensure a high speed of data recording and reading when disk arrays of the server become physically incapable of manipulating the obtained data while processing of high-quality HD (High Definition) video material. Later the information is transferred to the hard disc array of HTTP server.

The server performs streaming procedures to the clients in HTTP protocol by establishing TCP [2]–[3] sessions.

This Apple concept realization is only compatible with Apples high-end devices such as iPhone, iPad, iPod Touch, MacBook, which means that the customer is obliged to use the hardware and software created only by this corporation.

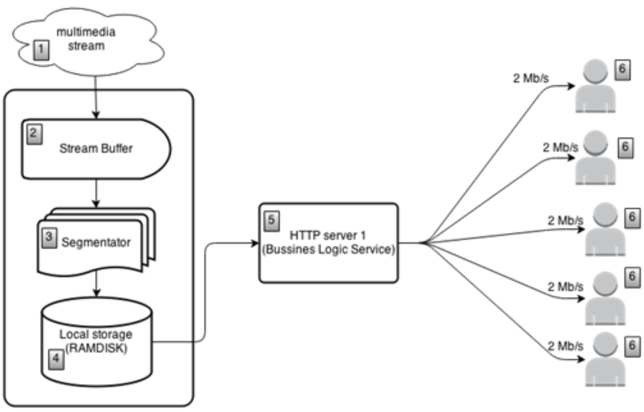

Fig. 1. Block diagram of the Apple HLS model: 1–4 blocks is POSIX system transmission, 5–6 blocks is networks system transmission

This model limits the development of other devices and prevents Internet market growth.

III. MODIFIED HLS MODEL

The HTTP Live Streaming traffic management software was ported into open source format, using C programming language, compiled with the GCC compiler. Most of the multimedia signal streams between the channels were replaced by protocol communication channels (SSL encryption was used). It has also been adapted to the stream distribution mechanisms that allow decreasing the transmission traffic and incorporating audiovisual (video part of the stream is dominating [4]) data stream into general IP network flow. This enabled the IP stream to be compatible with equipment of various manufacturers and get much better systemic and network load characteristics. Modified HLS model is shown schematically in Fig. 2.

Intermediate servers are installed in the modified model - Intermediate (Cache) servers, which distributes traffic to each other. These servers work in peer-to-peer mode, thus reducing the routes of data accessibility to the users and reducing response times.

This enables the user with possibility to connect any of the closest intermediate server which updates its database with necessary parameters in real-time. So, in this case, the data flow to the intermediate server and between intermediate servers is not transmitted constantly but according to the users' request. Data exchange is performed between network devices that are the closest and have the best bandwidth and accessibility parameters. They are used to send information to an intermediate server which can be addressed by the user to receive required information.

Relations in this modular system are multi-type – POSIX [5] subsystem signals (between blocks 1 – 4) and IP packets data (between blocks 4 – 7). POSIX subsystem signals are formed in the POSIX kernel bottom layer, they are local and not transmitted to the remote servers. Meanwhile IP packet data is transmitted via telecommunications network by Ethernet signal. So HLS module becomes broken up into two parts that use two types of signals this way optimizing the use of module resources and ensuring the stability of performance.

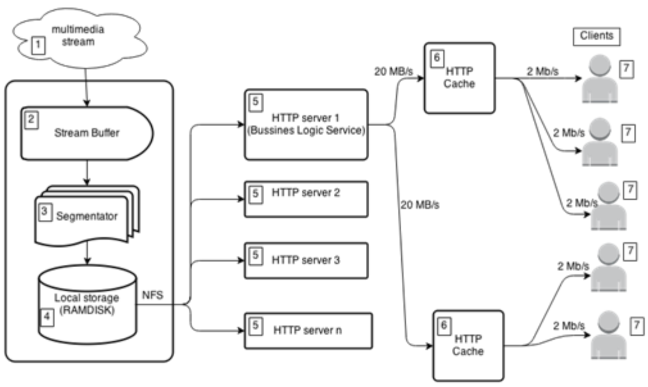

Fig.2. Scheme of the Modified HLS model: 1–4 blocks is POSIX system transmission, 5–7 blocks is networks system transmission

Developing software the usability of Internet channels connections was taken into consideration in order to create autonomously functioning system which consists of remote network modules. IP communication channels have been designed in several stages.

The first stage included the activation of set protocol to establish a connection between the system modules. The NFS (Network File System) protocol, which uses ISCSI (Internet Small Computer System Interface) extensions, was chosen for data exchange between systemic POSIX subsystem and HTTP server. The aim was to facilitate and expand the possibility of the connection between HTTP server and the subsystem of segmentator.

This was done by means of programming, creating NFS access to the RAM subsystem (after giving it networking ports and activating the software to exchange data in NFS protocol) and programmatically connecting to the HTTP port of the protocol corresponding server to perform the task of broadcasting. This connection feature can only work if the web-enabled devices (communication lines), which transmit the information, are of extremely high-quality, high-speed (channel data rate of around 1 Gbps) and of a high bandwidth.

To ensure the stability of Information transmission the restriction for the core operations of software channels occurred. This restriction is introduced to the protocols to prevent the protocol errors in packet networks. Due to the fact adaptive interconnects (between blocks 5 – 6 and 6 – 7) were used, which allows the Cache servers to make data transfer only on client request. To solve the problem of adaptive connection the cache (temporary storage roaming) method was used. This solution was implemented with reprogrammed Squid software package that was installed in cache intermediate server and intended to temporarily store Web page metadata (images, tables, etc.).

In this case the cache intermediate server operates not as a standard server, but as rebroadcasting server adapted to audiovisual broadcasting and able to balance network load accumulated between adjacent servers. The client while connecting to an intermediate point uses its granted resources without directly increasing the load HTTP server. If quantity N of concurrent users are watching the same channel, an intermediate server calls HTTP server downloads the necessary audio-visual information only once and distributes it to N users. This network management principle allows the Unicast signal transmission to compete with the Multicast method of group streaming.

The second stage was to improve the traffic safety parameters. For this purpose the HTTP server and the intermediate servers were linked to each other through SSL tunnels [6]. After the encryption of data exchange session via SSL tunnels, the possibility to take unauthorized audiovisual content information was significantly reduced.

IV. RESULTS

Stream and user parameters. The purpose of this research was to measure and compare several TV data streams parameters in various unmodified and modified HLS model locations. Primary research data is presented in Table 1.

Multicast streams. Multicast streams survey was conducted using HLS models which were discussed above by connecting them to the GPON optical network. Multicast stream was measured at the HLS model points that are presented in the Fig. 3.

TABLE I. USER AND STREAM PARAMETERS

The number of channels in Mcast signal	62
The number of watched channels during the study	10
Number of users	50
Channel stream, Mbps	2
Duration of the study, h.	168

The specifics of Multicast signal transmission is in the fact that the required information is sent to all clients at the same time. However, this broadcast method can be applied only to fully homogeneous network, which has no additional network nodes. The network topology of GPON, FTTH, etc. telecommunications is usually of ring architecture, where network information is distributed to clients through network distributors and such networks don't have adaptive stream control subsystem. The continuous stream is transferred by this network is sensitive to data signal delays, different traffic bandwidth changes, that is why all the available TV channels information is sent continuously at the time. Such a network data stream measurements were carried out at the points of measurement No.1 and No.2, and the results are presented in Fig. 4. Curve 1 and 2 reflect the essential Multicast signal transmission characteristic – the stream is transmitted to the transfer server and then to the client at almost the same rate with 3Mbps within the range.

Unicast streams in unmodified and modified HLS models. Two types of measurements using Unicast streaming technology were performed. First type of the case is unmodified HLS – measurements were done in the data bus between blocks 5 and 6 (see Fig. 1), second case is modified HLS – measurements were done in the data bus between blocks 5 – 7 and blocks 6 –7 (see Fig. 2). The sum of recent measurement is identical to the conditions of measuring point Nr.2 in the Multicast broadcasting case. After making the measurements Unicast traffic speed and transferred data volume dependency were obtained, at the unmodified and modified HLS broadcast methods. Fig. 4 and 5 show the curves of stream distribution at the observation time, which characterize the features of these broadcast [7].

In the case of unmodified HLS model the stream was transmitted by Unicast transmission method. The streams distributed highly dependently on the amount of customers connected to the server. Since during the study there were 50 clients with traffic of 2 Mbps for each user, the stream formed by all users was of 100 Mbps (it is presented in the Curve 3).

Curves 4 and 5, shown in Fig. 4, present uneven streams distribution in the time interval in the case of modified HLS model. This unevenness is obtained due unequal TV channels viewing in a week period. During the study, it was observed that clients usually are watching 10 TV channels (forming most popular 10 channels). This client behavior allows optimizing the communication channels and network devices work according to the amount of information needed. In the modified HLS model this optimization is performed by Cache server, which disables clients from creating new sessions with HTTP server and allows using the already existing temporarily indexed Cache server data.

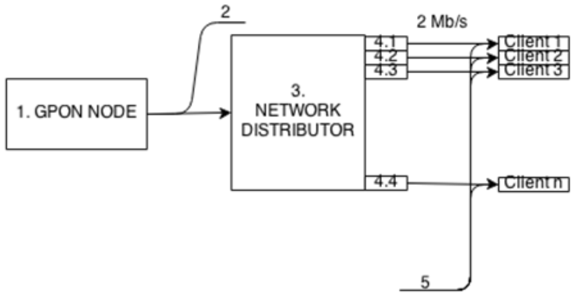

Fig.3. Schematic of streams measurement points layout: 1 – GPON network node, 2 – measurement point Nr. 1, 3 – IPTV data stream, 4 – network distributor, 5.1 – 5.n – customer stream ports, 6 – measurement points No. 2.

The Cache server activity is represented by distribution of the amount of information transmitted in real-time (curve 5) is presented in the Fig. 5. By comparing unmodified and modified HLS streams, it can be seen that the stream of is smaller in the case of modified HLS data transmission model. By selecting the optimal Cache server settings even better results created by modified HLS can be expected.

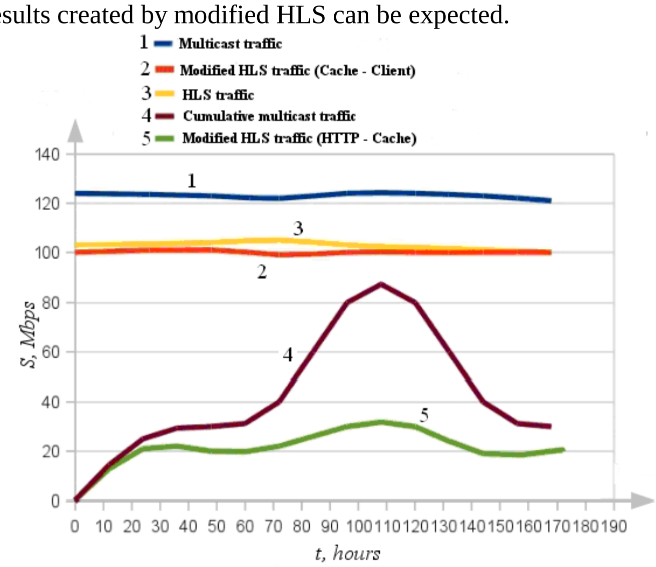

Fig. 4. The distribution of network random realization data traffic in real time

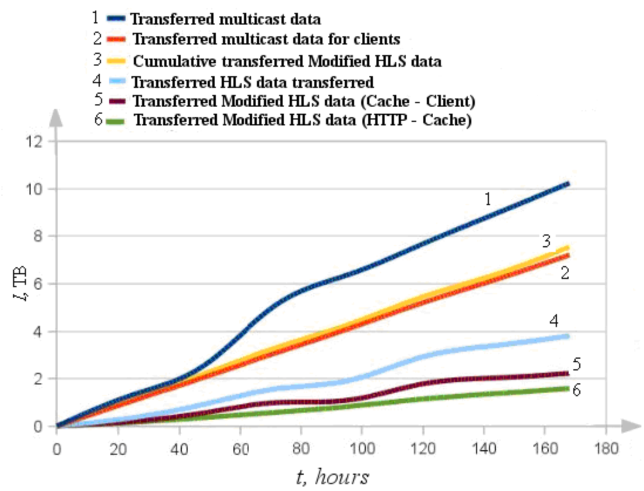

Fig. 5. The distribution of network random realization data amount in real time.

V. Conclusions

1. The user can receive data using modified HLS model by Unicast transmission method.

2. This modified HLS streaming service accessibility and equipment supporting overcomes Multicast transmission method.

3. Operating HLS model allows the use adaptive streaming cache mechanisms, which according to statistical criteria.

4. HLS allows to maximally optimize the stream distribution to the users and allows the customers who use mobile or small speeded connection to access the data.

5. Modified HLS model allowed to increase the security of data sent.

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Saulius Japertas, Assoc. prof., head of Telecommunications department of Kaunas University of Technology. PhD was received in 1991. The area of interest is Wireless Telecommunications and Telecommunications (included Cyber) Security. Have published papers in various fields of telecommunications and information technology.

TautvydasBaksys, M.Sc. of Telecommunications, Virtual Center of Excellence Telecommunications department of Kaunas University of Technology. The area of interest is POSIX systems, Cloud and Virtualization solutions, Digital Video Broadcasting methods and development.

Tautvydas Zelvys , M.Sc. of Computer Science. Virtual Center of Excellence, Telecommunications department of Kaunas University of Technology. The area of interest is C/C++ programming, embedded systems, parallel computing solutions and evolvement.