Інформаційні та комунікаційні технології в Internet та World Wide Web

Mathematical scheduling models of IPTV peer to peer networks

Nikolai Moskalets[1], Ekaterina Popovskaya[2]

Telecommunication systems department, Kharkiv National University of Radioelectronics, UKRAINE, Kharkiv, Lenina Ave.,14,
E-mail: 1. tkc2006@ukr.net, 2. katerina77popovskaya@ukr.net

Abstract – An alternative solution to support the growth of video services turned out to be peer video network. A mathematical models of peer networks that can be used when designing the network and display the dynamic properties of the organization and re-loading control of network resources is received.

Keywords – mathematical model, peer-to-peer, network, IPTV, scheduling,QoE.

The dynamics of the network states can be analyzed regarded as the schedule construction, providing an orderly presentation of fragments of TV content [1].

Dynamics of simulated network states is varied and can be presented on several levels. On the upper level we should consider a process of load change of m – channel by n – users. The middle level can be considered as state of n – users, that consequentially scan plurality of programs M. Finally, the lower level of the simulated network should be defined in relation to the dynamics of incoming fragments on terminal buffer.

The mathematical model of peer to peer network state can be built against to n – user applied m – channel or using state of m – channel quantitatively considering the appropriate load. At the beginning we consider feature of mathematical models construction of an individual peer to peer network user that viewed m – channel. The main challenge in P2P TV networks is to provide high-quality reproduction characteristics for an individual user (QoE – Quality of Experience), including continuity of viewing and a minimum of time to download the desired file [2].

Let us consider formalizing behaviors of n – user from the perspective of the finding an optimal schedule for its functioning. On one device (peer terminal) it must serve l – requirements (fragments of video). At any time, the terminal receives not more than one fragment and by the user decision the service process can be interrupted at any time to procced to viewing another channel. For every j – fragment belonging to the set $L = \{1,2,\ldots,l\}$ parameters are specified:

• the time of admission $t_j \geq 0$;

• duration of service $\tau_i = \tau > 0$;

• a weighting factor $w_i = w_j \geq 0$ that determines the significance of *j*- fragment.

Without loss of generality, we can assume that as a result of fragmentation all the fragments have the same volume. The challenge is to determine the order in which the fragments derived from different peers, served in the correct order within the minimum time. We will seek the required order in the form of schedule *r*, defined as a piecewise – constant continuous function $r: R \to \{0,1,2,\ldots,l\}$. Obviously, if the next *j*- fragment is served, then the function *r(t)* is $j \in L$, in the case of downtime is *r(t)*=0. Due to the fragmentation problem has an integral nature, so on the timeline we will consider the points *t* defining the position of a fragment.

For a particular file loaded by peer function *r(t)* has a beginning and an end. The start of service r_j is defined as the smallest integer *t* such that $r(t+1) = j$. The end of service C_j is defined as the greatest integer *t* such that $r(t) = j$.

We choose optimality schedules criterion *r*.

Let $T(r)$ represents the total weighted end value:

$$T(r) = \sum_{j=1}^{i} w_j C_j \to \min \qquad (1)$$

The values of weighting coefficients w_j may not be the same as the importance of subsequent fragment to the minimizing of (1) increases. This suggests that $w_1 \geq w_2 \geq \cdots w_i$.

The result is that we can find a schedule $\hat{r}$ that achieves a minimum value of the function (1). In the absence of interrupts to solve this problem the nominal algorithm with complexity $O(n^7)$ operations is known.

Conclusion

1. The advantages of using peer to peer technology are: ablity to significantly reduce the network load, to maintain the quality of the transmitted content, to organize live broadcasts with minimal delays, etc.

2. Functional mathematical models can be constructed from the perspective of macro network performance that indicates the state of *n* – users viewing *m* – channels. Micro approach is based on consideration of the optimization problem buffer loading fragments of content. At an intermediate approach should be considered activity model using the corresponding channel.

Literature

1. Setton E., Girod B. Peer-to-Peer Video Streaming// Springer. – 2007. – 150 p.
2. Popovskij V., Barkalov A., Titarenko L. Control and Adaptation in Telecommunication Systems, Springer-Verlag Berlin Heidelberg, 2011.