ON A METHOD TO INCREASE THE EFFECTIVENESS OF CABLE VOD SYSTEMS

Lidia T. Jordanova[1], Jordan I. Nenkov[2]

1. Faculty of Telecommunications, Technical University, Kliment Ohridski 8, 1756 Sofia Bulgaria
2. Faculty of Telecommunications, Technical University, Kliment Ohridski 8, 1756 Sofia Bulgaria
e-mail 1: jordanova@tu-sofia.bg
e-mail 2: Jordan_n2002@yahoo.com

Abstract

The paper deals with the special features of the VoD service provided over now-a-days CATV networks. A VoD system of the hybrid type is studied, two implementations being considered: the first one making use of proxy servers to redirect the video traffic from the core network to the distribution hubs and the second one using no proxy servers. A concept for the design of CATV networks supporting the VoD service is given. It refers to the choice of: architecture, movie content distribution algorithm, routing protocol to determine the path of the chosen video stream from the server to the subscriber. Movie content distribution strategies based on the Pareto distribution are discussed that take into consideration the subscribers' preferences and refer to the hybrid-type system. Such strategies aim to decrease both the video traffic across the core network and the cost of the network equipment involved.

1. INTRODUCTION

The contemporary VoD systems implementation is based on the intelligent approach, i.e. on the system managers. The system managers coordinate the video content distribution on the VoD servers according to subscribers' preferences and they decide the VoD stream path according to the chosen routing protocol. They can perform the system self-test and the system blocking prevention too.

Depending on the interaction degree, a VoD system can be categorized as follows [1]:

Quasi-Video-on-Demand (QVoD): In this case the users are grouped based on their interests. A user can choose between different programmes by changing user teams.

Near-Video-on-demand (NVoD): The same programme is retransmitted in fixed time slots thus enabling functions such as forward and reverse play.

True-Video-on-Demand (TVoD): The user has full control over the presentation of the programme. The T-VoD fully simulates a VCR (Video Cassette Recorder) enabling functions such as forward and reverse play, freeze and random positioning.

Adaptive-Video-on-Demand (AVoD): In this case the user submits a request for a movie and the decision is made through a routing algorithm.

In this paper the hybrid type VoD system is present, which is a mix between the QVoD, TVoD and AVoD models. The existing CATV system is used for the VoD system realization. The aim of the research is choosing the more appropriate network architecture, video content distribution algorithm and routing protocol determining the video stream root in its transfer between the video server and the subscriber.

2. BUILDING CONCEPT VOD ARCHITECTURE

VOD systems can be deployed in one of three fundamental architectures – centralized, distributed and hybrid [2-3]. The investigations here described are based on the hybrid VoD architecture, which operational diagram is illustrated on Figure 1. In the following approach the biggest VoD platform that is supplied with a large library of movies and program content is installed at the head-end. The smaller VoD servers are located at the distribution hubs (DHUBs) and are limited in both size and storage only for the most popular movie selections.

The realization of the contemporary hybrid type VoD systems is based on the hierarchical approach, as the number of hierarchical levels is commonly three [4-5].

The edge VoD servers are located on the third hierarchical level, which holds the most frequently requested movies for the corresponding subscribers' group. The video stream transfer is performed from these servers to subscribers. These servers can perform proxy servers' functions, which redirects the video stream from another server, which holds the requested movie to the subscriber. On the second hierarchical level the VoD servers with the most saved requested movies for the corresponding region are located. Between them and the edge VoD servers, an information which contains the number of requests for the corresponding region is exchange periodically. The number of requests is different for each separate group. The Edge nodes are updated periodically according to the subscribers' preferences. On the first hierarchical level is located the Head-End (HE) which coordinates all system performance.

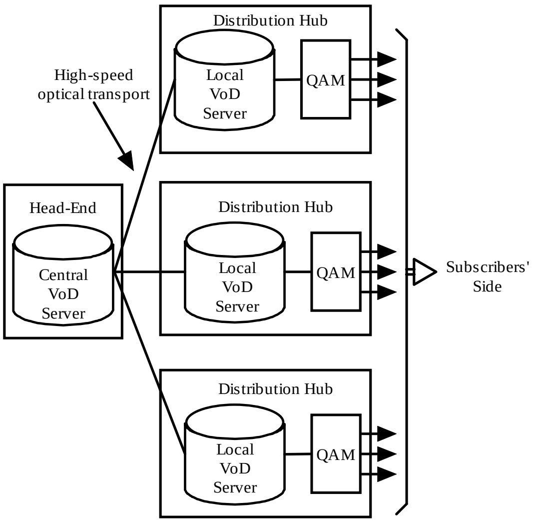

Fig. 1. Hybrid VoD system architecture

With the contemporary VoD systems realization, two main approaches are applied – direct and indirect, which nature is described on the Figure 2 and Figure 3.

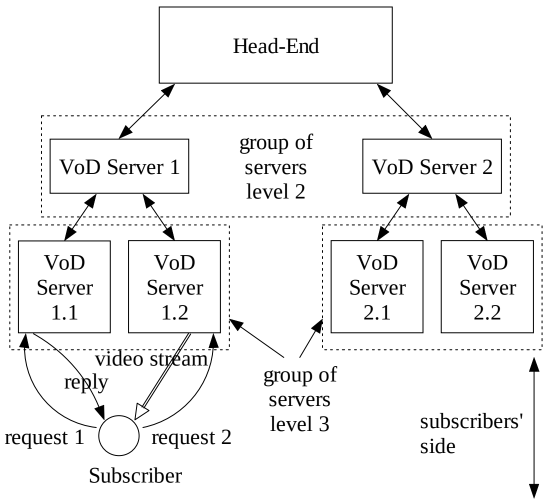

Fig. 2. Direct VoD transfer

The operational algorithm of the model, which is shown on the Figure 2, is following: The request for movie is sent from subscriber to server 1.1. The request arrives at server 1.1 and gets forwarded to its manager (server 1). Server 1 finds that server 1.2 holds a copy of the movie and has an acceptable load. Server 1 then replies to 1.1 which replies to the user that server 1.2 is capable of playing the movie. Server 1 then informs server 1.2 that it is expected to receive a request from the user to get the movie, and server 1.2 reserves (for a limited period) the necessary resources for the request. Eventually, the user opens a connection with server 1.2 and gets the service directly from it. After the user request is done, which consist of the movie name and VCR commands, the video stream transfer can be performed.

In the Figure 3, the operational diagram is present, where the requested movie is not located in the local region, or all local servers that hold a copy are overloaded. However, server 1.2 which holds the requested movie is overloaded, but it can still serve as a proxy yet. The manager (server 1) forwards the request to its parent (in this case the HE). The HE observes that a copy of the requested movie can be played from server 2 and informing server 2 for this action. Server 2 finds that server 2.1 is capable of playing the movie, i.e., it has a copy of the movie, it has a connection to the private network and its load is acceptable. Finally, the user contacts server 2.1 and requests it to play the movie through server 1.2 (proxy server).

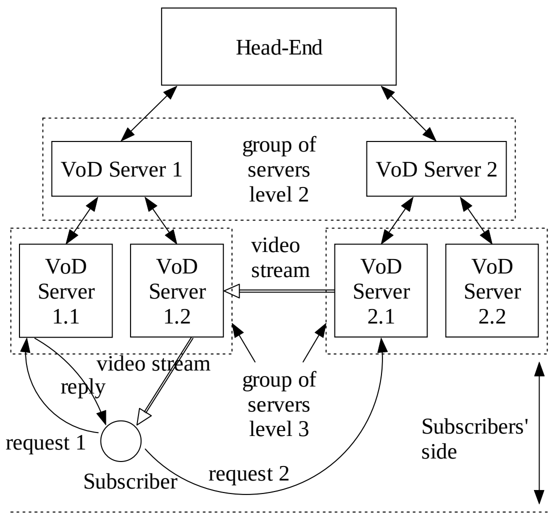

Fig. 3. VoD transfer via proxy

3. ALGORITHMS FOR VIDEO CONTENT DISTRIBUTION

In this work two algorithms which are based on the subscribers' preferences are described which automatically distributes the video content from the head-end to the distribution hubs. The two algorithms are distinguished in terms of using stage the local servers' disk capacity and the requested movie delivering method from video server to the respective subscriber, when the requested movie is missing from the local server. For these algorithms the following abbreviations are introduced: FDUCDA (Full Disk Using Content Distribution Algorithm) and PDUCDA (Partial Disk Using Content Distribution Algorithm).

The diagram on Figure 4 illustrates the algorithms operation.

The DHUBs are set apart in logical zones each one containing one or more DHUBs and serving the subscribers whose video preferences are similar [6]. Initially, the whole video information is recorded onto the central server, then duplicated onto the local servers but only for the movies that are supposed to be most preferred. After that the algorithm keeps on self-learning with the existing data in the network so that the video content in the distribution hubs is updated automatically through specified time period (from one to up to several days, according to the requests intensity).

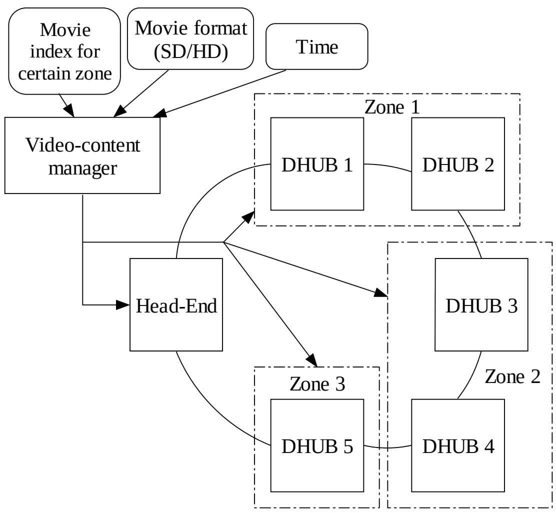

Fig. 4. Operational diagram of the algorithms for video content distribution

The update should be done at a given moment to avoid the risk of blocking the system. The morning period is chosen between 5 AM and 6 AM, when the video traffic intensity is at its minimum for the local servers updating. The update consists of deleting some of the old video content and recording a new one, data about the popularity of each movie being taken into consideration.

It is important to note that to compensate for the different transmission bit rate of the movies in Standard Definition (SD) and High Definition (HD) format the HD format movie index must be multiplied by four. Besides, HD-formatted films have a bigger file size if compared with SD movies though their duration in minutes is still the same. Because of that reason the percentage of HD movies with respect to the overall number of films should be considered when the necessary disk space is scheduled.

Information about the movie index is collected and updated case-by-case for each zone. If a movie is requested but the video session duration is less than 20 minutes its movie index is not changed.

When the index of the old video content in the local servers is less than a given threshold it will be deleted and replaced by a new one whose index is above the threshold. The threshold depends on the local servers capacity (the disk space in GBytes).

As it is seen from the analysis in [3] the local servers capacity, in terms of FDUCDA using, has to be chosen in a way not to be less than 23% of the central server capacity at the head-end. With this approach it is guaranteed that at least 80% of the requested movies will be available in the local servers of each zone. If the local servers capacity has not been properly calculated the system would not function efficiently. Smaller capacity causes both a video traffic increase and a risk of system blockage, but on the other hand huge capacity leads to increased equipment expenses.

The local servers' capacity in terms of PDUCDA using is chosen to be 25 % larger for each local server, compared to local server's capacity in terms of FDUCDA using. This 25 % additional disk capacity is reserved for recording the requested movies from other serving zones. In this way the risk of system blockage is decreasing, but the largest disk capacity leads to increased equipment expenses.

The PDUCDA operates as follows: If a movie, which is not recorded at the local server, is requested by the user, this movie is downloading from the other local servers through Peer-to-Peer (P2P) protocol. On that way the multiple information streams with low bit rate are used which leads to minimizing the risk of system blockage compared to proxy server using with high video stream bit rate (3,75 Mbps for SD and about 12,5 Mbps for HD video).

During the movie downloading (this time can be minimized to some minutes with the contemporary high-speed optical transport usage), the subscriber waits. After the video session ends, the movie is deleted from the local server.

In case the local server contains films whose index is equal to 1 or more than 1 (e.g. movies requested at least once), small space of this server will be unused. Onto this unused space the operator will record random films with a zero index. This case is possible in the initial phase of the algorithm operation when the video information gathered is still not enough.

After the local servers is updated with new video content the system must decrease the traffic through the central distribution network in order to reduce the blockage risk.

When a subscriber requests a movie and meets the access conditions the movie transfer starts by the nearest point. Firstly, the system checks for the requested film within the local server, after that in the other DHUBs and finally in the head-end.

The decision for the transfer route depends on the routing protocol. This protocol takes into consideration the number of the points to the movie location and to the subscriber, as well as the traffic into the different system parts.

The video-content manager block can be realized as a software application that will automatically copy and delete movies on the local servers. In that case a criterion must be developed in order to minimize possible mistakes and system blockage. For example, during an existing video session to a certain subscriber the chosen movie must not be deleted. During the video-content update the transfers to subscribers must be avoided. During the server update process the server operates as a transit unit which redirects the requests to the DHUBs or to the head-end in terms of FDUCDA using.

4. ROUTING PROTOCOLS USING IN VOD SYSTEMS

Routing protocols are used in CATV networks for the chosen video stream path determination with its transfer from the video server to subscriber. After the routing protocol takes a decision for the requested video stream path determination, a record in routing table of each router on the video stream path is made.

There are two main types of routing protocols [7-9]:

1) Centralized – the choice for route is made from the main controller, which is located in the HE. This controller updates routing tables of all routers, located in different nodes. The advantage of this type protocols is decreasing the risk of system blockages but disadvantage is their impossibility for large geographic area deployment.

2) Distributed – the main controller is not necessary and the needed information about the route choosing is adopted from other routers through the messages exchange with their adjacent routers. This type routing protocols are realizable in large scale CATV networks. They are the more applicable for the contemporary network realizations.

In terms of CATV networks routing protocol composing, it is needed to take place in account with theirs three-and-branch topology. The suitable routing protocol realization over the CATV network is illustrated on the Figure 5. It is typical for this protocol that the route choosing is made by each router through sending the requested messages to adjacent router in upstream direction.

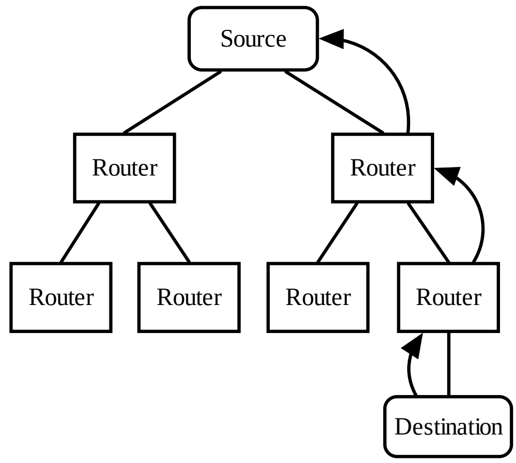

Fig. 5. Routing protocol realization over the CATV networks

The felicitous reason is using the routing protocols as a Border Gateway Protocol (BGP), which can be realized over the large scale networks as a contemporary CATV networks.

These types of routing protocols enable managing as the direct information between two adjacent routers as a transit traffic generating with the proxy servers using.

5. CONCLUSION

In this paper is presented a method for increasing the effectiveness of VoD system, realized over the CATV network. This method consists of optimization the network architecture, video content distribution algorithm and routing protocol.

Two video content distribution algorithms are proposed – FDUCDA and PDUCDA. From their comparison the following conclusions can be made:

1) FDUCDA require smaller local servers' disk capacity for its realization which make this protocol more inexpensive but it is increasing the traffic

across the central transport network, i.e. the risk of system blockage increase too.

2) PDUCDA requires 25 % additional disk capacity, compared to FDUCDA. The advantage is higher reliability, i.e. the lower probability of system blockage but disadvantages are the higher price compared to FDUCDA and more time is needed when subscriber waits for the requested video passing.

It is present a routing protocol building concept over the CATV network, ensuring effective transmission of the requested video streams from the VoD server to subscribers.

References

[1] C. Bouras, J. Garofalakis, P. Petridis and G. Tzimas, The performance of queuing theoretic vodeo on demand algorithms, 2007.

[2] Fujitsu Network Communications Inc., Fujitsu Gigabit Ethernet VOD Solutions, USA, 2004. [Online]. Available at: http://www.fujitsu.com/downloads/FNC/Whitepapers/VOD_wp.pdf.

[3] L. Jordanova, J. Nenkov, Distribution of Video-on-Demand Service over Cable Television Networks, *Journal Radio engineering*, Volume 18, Number 2, June 2009.

[4] Al Hamra, E. Biersack, G. Urovoy-Keller, Architectural Choices for Video-on-Demand Systems, 2003. [Online]. Available at: http://2003.iwcw.org/papers/alhamra.pdf

[5] Roytman, DVS: A System for Distribution and Management of Global Video on Demand Services., Israel Ben-Shaul, Israel Cidon, 1999.

[6] M. Pasquinilli, S. Nakrani, The Benefits and Challenges of Deploying Large Regional VOD Asset Libraries, *NCTA Technical Papers*, 2008.

[7] http://www.cse.buffalo.edu/~qiao/cse620/fall04/adaptive.ppt.

[8] Abdullah M. S. Alkahtani, M. E. Woodward and K. Al-Begain, An Overview of Quality of Service (QoS) and QoS Routing in Communication Networks , University of Bradford, UK, 2003.

[9] https://cisco.hosted.jivesoftware.com/servlet/JiveServlet/download/4770-2-4102/cisco-360-IGP-Data-Sheet.pdf.