

Implementation and Quality Assessment of a User-Centric Adaptation System for DASH

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ABSTRACT

In recent years, dynamic adaptive streaming over HTTP (DASH) has been widely used in order to let the viewer have an uninterrupted streaming and therefore higher quality-of-experience (QoE). The technique basically relies on dynamic rate adaptation by downloading the video at lower qualities according to various network conditions. However, many issues are open related to client-side rate adaptation. For example, current DASH systems do not yet let the viewer decide which aspect of quality of the video should be reduced first and which aspect of quality of the video should be stable. This paper presents a novel adaptation system for DASH which is designed to search whether a higher QoE might be achieved if the adaptation method could be user-centric. During subjective quality assessment, it has been observed that all the participants have had a higher QoE compared to regular DASH system when they were given a chance to decide the way of adaptation.

Keywords:

Adaptive streaming; MPEG-DASH; User-centric; SSCQE; QoE.

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INTRODUCTION

Significant and fast developments in network services and smart mobile devices over the last decade have led to large growth and progress in media streaming. Eventually, old applications running on UDP and using the RTP/RTSP protocols have been replaced by new applications that use the HTTP protocol running on TCP. VoD and IPTV companies such as Apple, Adobe, Youtube have developed and used HLS (HTTP Live Streaming) [1], MSS (Silverlight Smooth Streaming) [2], HDS (HTTP Dynamic Streaming) [3] and DASH (Dynamic Adaptive Streaming over HTTP) [4], which are all HTTP based adaptation protocols. The DASH standard was introduced by MPEG to make efficient video streaming over the Internet [5]. This standard is based on the same video or audio content being encoded at different bit rates and kept on the server as small HTTP file segments and the adaptation is made on the client side by considering network conditions and buffer status. To play the content, the DASH client first obtains the manifesto file. By parsing the file, the DASH client learns about the segment duration, media-content availability, media types, resolutions, minimum and maximum bandwidths, and other content characteristics. Using this information, the DASH client selects the appropriate encoded alternative, and starts streaming

the content by fetching the segments via HTTP GET requests. After appropriate buffering to allow for network throughput variations, the client continues fetching the subsequent segments, and monitors the network bandwidth fluctuations. Depending on its measurements, the client decides how to adapt to the available bandwidth by fetching segments of different alternatives (with lower or higher bitrates) to maintain an adequate buffer.

On the other hand, the main goal of modern video streaming services is to find out how to transfer content over the network for the best Quality-of-Experience (QoE). The constant bit rate coding in the DASH system affects QoE in different ways: First, encoding different video content at the same bit rate results in different QoE. Second, the effect of different bitrate allocation options on QoE. Currently available systems use DASH, but do not leave the user with the choice of which features of the video will change when the available bandwidth changes. In this study, a user-centric adaptation system is proposed which allows the user to decrease quality depending on the QoE preferences. Before the streaming begins, the user is asked to select the QoE preferences by voting which feature is to be waived in the first place as a bitrate drop during the flow. In other

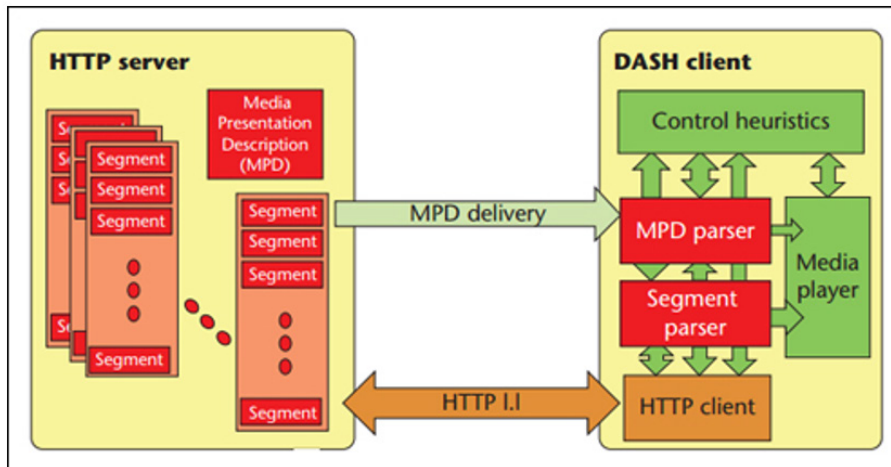


Figure 1. MPEG-DASH system [5].

words, the questions about which features will be more variable, and which features will remain unchanged as much as possible are asked to improve the QoE.

In the literature, a few studies have been suggested to develop adaptation based on user-perceived quality rather than the best media bitrate and bandwidth compliance. In [6], a segment selection algorithm was developed in which users could opt for a smaller amount of data to the player's buffer for a smoother streaming experience compromising the image quality or an image quality with better stability. In [7], a method for streaming over mobile networks is proposed to provide users with a more efficient flow by grouping and multicasting them according to the relevant video version and the base station to which the user is connected. In another study, user-centric functions have been developed to determine the effects of initial delay, freezing and image quality changes on the users QoE in the sight of subjective test results [8]. In a DASH system using scalable video encoding, it has been demonstrated that by using different image quality options, the initial waiting time is reduced, but these quality changes and low quality images reduced the user QoE [9]. In a DASH system developed for mobile devices [10], it has been suggested to collect data such as user presence, proximity to the screen and motion, screen brightness, and ambient lighting with sensors on the mobile device and to use them for better QoE. Although it is agreed that the adaptation algorithms must be designed considering not only available network resources but also the user's needs, the user has not probed yet for preferences about adaptation and quality switches.

MATERIAL AND METHODS

The working technique of MPEG-DASH is shown in Fig. 1. In the MPEG-DASH technique, the media content exists on an HTTP server in two parts. The video or

audio content is encoded at different bit rates and divided into one or multiple consecutive media segments. A manifesto containing information on the properties and locations of the segments as URL addresses, the XML file named MPD (Media Presentation Description), is kept on the server with these segments. Each segment has an addressable location on a server that can be downloaded using HTTP GET or HTTP GET with byte ranges. When the first connection is established, the client can access all the information to be tracked by fetching and parsing the MPD file. Then, on the client side, the video segment of the bit rate appropriate to the TCP throughput is requested from the server, monitoring the status of the connection, repeatedly. When the connection speed changes, switching between different bit rates allows the video to be watched without interruption. In case of bandwidth changes, it is decided by the control heuristics module that the segment file which is suitable for the calculated bit rate for the next segment/s will be requested; the requested segments are transmitted simultaneously from the HTTP server to the segment parser module in the DASH client.

The DASH technique aims to adapt to the changes of the network by changing the bitrate of the video and audio, namely switching the quality factors such as SNR (Signal-to-Noise Ratio), FPS (Frame-per-Second), and so on. Which feature of the media, (such as resolution, fps, audio bitrate etc.), will be encoded in which bitrate must be predetermined. The video and audio content is encoded to fulfill the fixed bit rate as the planned/manifested values and divided into segments of equal length in time.

We propose a novel system that allows the user to determine the DASH adaptation method. The web pages shown in Figs 2 and 3 are presented to the user as the option of selecting and determining the priority order. At the



Figure 2. Web page for the first stage of priority determination.

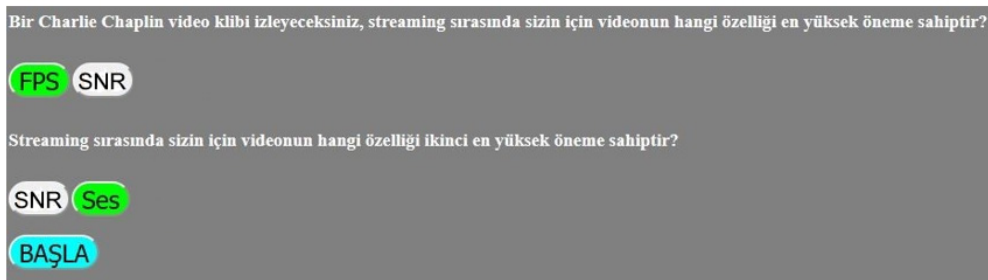


Figure 3. Web page for the second stage of priority determination after selecting FPS at the first stage.

first page the user is asked to prefer between SNR and FPS quality of the video. At the second page the user is asked for to prefer between audio quality and unselected video quality. Thus, the user determines which aspect of quality of the video should be reduced first and which aspect of quality of the video should be stable. Table 1 shows four different adaptation methods and the corresponding quality priority orders.

To implement user-centric adaptation system for DASH, The Bitmovin Adaptive Streaming HTML5 Player is used, which supports MPEG-DASH and is free for open-source and commercial purposes [11]. Four different pages are created with embedding DASH.js to use related source videos and MPD files. The segmentation process is performed using MP4BOX [12] and the relevant segment and mpd files are stored in related folders. The corresponding paths

of the segments prepared are indicated on the page where the DASH player is embedded.

To examine how the user can perceive a higher QoE with the user-centric system, the new system is compared

Table 1. Adaptation methods.

Adaptation Method	Priority #1	Priority #2	Priority #3
1	FPS	SNR	Audio
2	FPS	Audio	SNR
3	SNR	FPS	Audio
4	SNR	Audio	FPS



Figure 4. The proposed QoE evaluation interface compliant with the SSCQE method of ITU-Rec. 500-11.

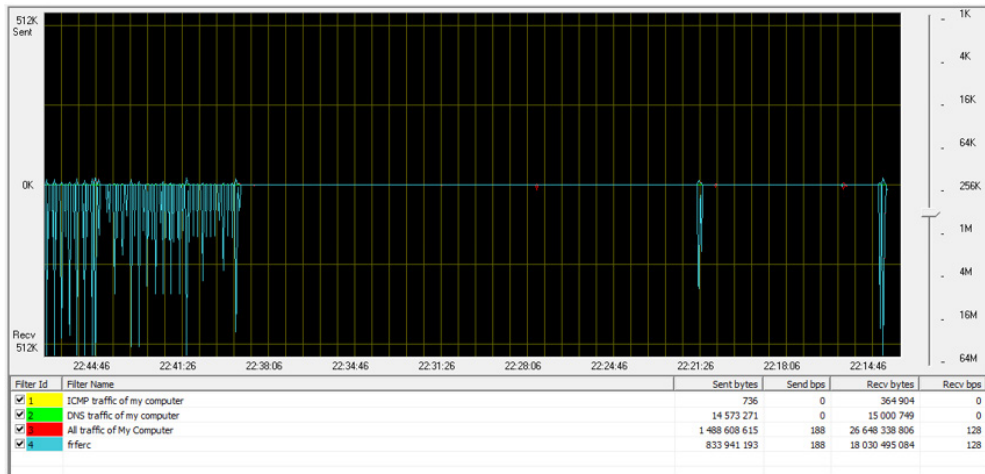


Figure 5. Bandwidth tracking with Tmeter.

to the default adaptation system which is unaware of user's preferences by using subjective quality evaluation. We propose to measure QoE by using SSCQE (Single Stimulus Continuous Quality Scale) method which is recommended for subjective quality assessment of video streaming applications in ITU-Rec. 500-11 [13]. An evaluation interface has been added to the top left of the page to enable on-the-fly evaluation on pages where the player is embedded. Every 5 seconds the viewer is requested to give a rating between 1-5 points as a voted QoE value. For example for a 30-second flow with a total of 6 evaluations, QoE rating is made over 30 points. The proposed QoE evaluation interface is shown in Fig. 4.

Each viewer firstly evaluates the default adaptation method and then the viewer selects the adaptation method according to his/her preferences. After making the selection, the viewer is directed to the relevant adaptation page and evaluates as the first part of the test. The scores obtained in the subjective evaluations are stored in the corresponding txt files, including the name and surname of the participant

and the date and time of the test. After each adaptation, the submission process of the evaluation result is directed to the page containing the relevant php code. The evaluation is recorded in the corresponding txt file of the adaptation evaluated by the php code.

RESULT AND DISCUSSION

The system was installed on a free subdomain with all the necessary files [14]. In order to observe the adaptation during the test, Tmeter [15] was used to limit the available bandwidth. As a result of practical observations, the free subdomain offered up to 4500 kbps and 1700 kbps in average of bandwidth for downloading. Considering the maximum bandwidth of 1600 kbps, it was decided to make a coding at fixed bit rates such as 1600 kbps, 1250 kbps and 850 kbps, with a difference of 350 kbps which could make a difference in perceptual quality. Bandwidth tracking and restriction examples with Tmeter are given in Figs 5 and 6, respectively.

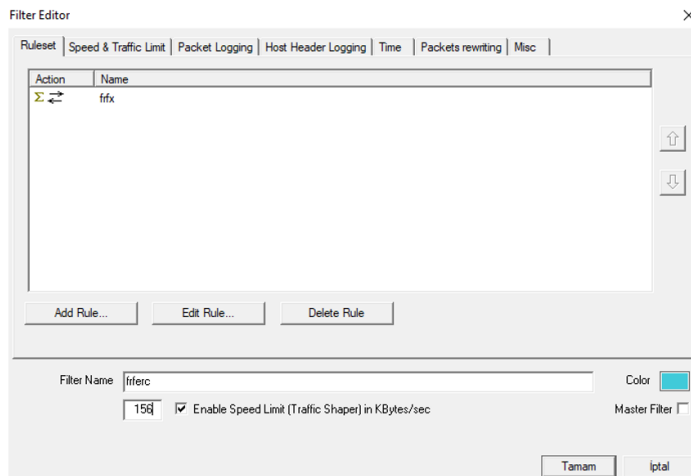


Figure 6. Bandwidth limiting with Tmeter (156 Kbps approximately 1250 kbps).

As a source of test content, a Charlie Chaplin video clip at 1280x720 resolution is selected and encoded with an H.264 codec. Table 2 shows how SNR, FPS, and audio bitrate allocations are made according to 4 different adaptation methods to suit 3 different total bitrates. Eq. (1) shows the total bitrate is calculated as sum of video and audio bitrates.

$$\begin{aligned} \text{Total Bitrate } (\sum \mathbf{BR}) \\ = \text{Video Bitrate } (\mathbf{VB}) + \text{Audio Bitrate } (\mathbf{AB}) \end{aligned} \quad (1)$$

A1: When the available bandwidth decreases from 1600 kbps to 1250 kbps, the audio bitrate is reduced to 185 kbps. When the available bandwidth decreases from 1250 kbps to 850 kbps, the video bitrate is reduced to 665 kbps. The 400 kbps drop results in reducing the SNR of the video since the FPS value is kept constant.

A2: When the available bandwidth decreases from 1600 kbps to 1250 kbps, the video bitrate from is reduced to 665 kbps, reducing the SNR of the video. When the available bandwidth drops from 1250 kbps to 850 kbps, the audio bitrate is reduced to 185 kbps.

A3: When the available bandwidth drops from 1600 kbps to 1250 kbps, the audio bitrate is reduced to 185 kbps. When the available bandwidth is reduced from 1250 kbps to 850 kbps, the FPS of video is reduced from 30 to 20, reducing the video bitrate 400 kbps down.

A4: When the available bandwidth drops from 1600 kbps to 1250 kbps, the FPS of video is reduced from 30 to 20, and reducing the video bitrate 400 kbps down. When the available bandwidth drops from 1250 kbps to 850 kbps, the audio bitrate is reduced to 185 kbps.

On the established system, subjective tests were conducted with 15 participants. In the first stage of the test, each participant was presented with the flow using the adaptation method #4 as default, and in the second stage,

Table 2. Allocation methods

	$\sum \mathbf{BR} = 1600\mathbf{k}$		$\sum \mathbf{BR} = 1250\mathbf{k}$		$\sum \mathbf{BR} = 850\mathbf{k}$	
	VB	AB	VB	AB	VB	AB
A1	1065k @30f	535k	1065k @30f	185k	665k @30f	185k
A2	1065k @30f	535k	665k @30f	535k	665k @30f	185k
A3	1065k @30f	535k	1065k @30f	185k	665k @20f	185k
A4	1065k @30f	535k	665k @20f	535k	665k @20f	185k

Table 3. Results of subjective tests as cumulative scores (A1: Adaptation preferred, A4: Adaptation default)

Assessor No.	A1	A4	Assessor No.	A1	A4	Assessor No.	A1	A4
1	25	18	6	25	19	11	21	17
2	23	16	7	23	16	12	23	13
3	18	17	8	27	15	13	26	14
4	23	19	9	22	15	14	27	17
5	26	16	10	23	17	15	27	15

the viewer was asked which adaptation method he would like to watch the same video. All participants preferred the adaptation method #1. The silent Chaplin video selected for streaming, although accelerated during construction like most old movies, has a standard FPS value (25). Instead of the audio quality and the video SNR value, the participants chose not to reduce the FPS value, but to watch the video in a fixed and original FPS. In other words, the most important video feature for the participants was the FPS value and the second was the SNR value. The audio bitrate was not important at all since the test video was from a silent film, having only background music. Note that, different type of contents might lead to different preferences. However, this research was kept as future work.

The cumulative scores of the adaptations are given in Table 3. The QoE value of the adaptation method #1 is computed as average 23.93 over 30; the QoE value of the adaptation method #4 is computed as average 16.27 over 30. The results show that QoE of the user-centric system is superior to QoE of the default system.

CONCLUSION

We proposed a user-centric system for DASH that allows the user to determine the quality adaptation method using preferences and priorities of the viewer. We observed that, when the viewer was given a chance to select the adaptation method, the flow quality assessments provided a higher quality of experience compared to the current DASH system in which the user was generally subjected to certain and single type of adaptation. The user-centric system could be extended by following the streaming experiences of the users, learning their preferences and/or network capacities and offering the user new adaptation methods in this direction. As another future study, it can be searched to merge adaptation decisions with objective QoE measurement methods.

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