Realization of subjective tests in the environment of streaming services

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***Abstract*—Increasing requirements on video quality seem to be essential while designing any video-oriented services. The methods in the user-centered design of services are fairly labor intensive and have to consider resulting value of user experience. However, user experience is a term that is currently very hard to be defined. There are different approaches to user experience assessment, which lack an ultimate method to predict expected user experience. In this article, we introduce a system that enables web service providers to measure quality of service provided to end-users while playing online video content that is approached via http progressive streaming. This tool is also suitable for future educational purposes in the field of video quality evaluation.**

I. Introduction

Nowadays, media streaming has become one of the most used network service oriented on multimedia. In the world of telecommunication service providers we see upward trend in providing of combined voice, video and data services. Video can be considered as a new feature in this scheme but it importantly change the whole aspect of the way how we work, live, learn and how we communicate between each other. Few years back YouTube was only a web-page where you went to entertain yourself while watching music videos. Nowdays we can consider YouTube as the second biggest search engine after Google and before Yahoo, which just underline the fact that video is potentially becoming the future source of information not just an instrument for entertainment. With the importance of user's mobility the corresponding multimedia services need to be highly reliable to earn the trust of it's customers. This is why we need precise assessment methods and frameworks to guarantee a specific level of user experience. In order to archive this goal we firstly need to consider which parameters have influence on degradation of user experience and quality of multimedia content. This has been done with signal-to-noise ration (SNR), peak signal-to-noise ration(PSNR) or bit error rate (BER). However, the latest measurements shown that they do not correlate well with quality perceived by an end-user [1]. Therefore, concepts such as Quality of Service(QoS) and Quality of Experience (QoE)[2][3] has been introduced. But most of the current approaches are oriented to one specific video content type/application or to one scenario which is not enough. Video quality metrics need to be more complex and cross-content to provide better correlation with subjective ratings that are really important for appropriate decisions on a suitable optimization method for video streaming.

In this paper we present a video quality measurement tool, a concept that is based on a real-time statistical data gathered at the client-side, which are lately send to a remote database. In order to explain the functionality of the measuring tool, we will firstly introduce the streaming technology that the tool is built on. Next, we will discuss the quality of video in context of http streaming, followed by identification of the factors that influence the resulted quality of service. These factors are key-components of our client-side video measuring tool. At last, we will analyze tool's functional topology and components it is composed of, with brief description of technologies and implementation process of the tool.

II. Foundation

In the following, we outline the main terms needed to understand the problematic of this paper.

User Experience: we can understand it as an experience that an user achieve during the process of interaction with a product or service. However, we have to have in mind that user experience is highly influenced by different factors like user expectations, experiences or state of mind.

A. Assessment of User Experience

There are several approaches that are used to measure video quality and corresponding user experience.

a) Subjective Quality Assessment:: the quality of perception is not a term that is exactly defined or can be easily computed. It is cause of fact that it is connected at most of the time with particular viewer. This viewer then can define the quality by his own scale and internal judgment. Therefore, the result is most of the time influenced not just by the quality of perceived video sequence, but also by specific state of mind of particular viewer. There are several standards that orient on subjective quality assessment of video and audio quality. They can be found in ITU-R Rec. BT.500-11[13] and ITU-T Rec. P.910[4].

b) Objective Quality Assessment:: on the other hand compared to the subjective quality assessment, objective quality assessment is a technique that is most of the time defined as a mathematical model for estimating of the subjective quality assessment. It builds on metrics that can be automatically evaluated by a computer. These metrics then are divided into three groups on account of availability of a reference video.

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- *Full-reference (FR) metric*: is a technique where we fully use reference video to compare its quality to test video. The whole process is done in two steps, the first step calculates the errors between original and distorted images and the second one has to pool the particular errors to a global quality assessment[14].
- *No-reference (NR) metric*: here we analyze only test video without the need to compare it with the reference video. However, this technique uses some prior information, like type of encoding to be able to look on codec-specifications.
- *Reduced-reference (RR) metric*: is a hybrid between FR and NR metric in terms of the reference information. This approach is suitable mainly cause of managing of the amount of reference information we use.

B. Mean Opinion Score (MOS)

We can defined *Quality of Experience* (QoE) as a number in range between 1 and 5 used to express level of quality in multimedia (audio, VoIP or video)[Tab. I]. MOS for voice is standardized in ITU-T R. P.800[15]. The value of MOS is acquired by subjective assessment tests, where the attendants rate the audio or video quality of the test sequence.

TABLE I
LEVEL OF QUALITY IN MOS

MOS	Quality	Impairment
5	Excellent	Imperceptible
4	Good	Perceptible, but not annoying
3	Fair	Slightly annoying
2	Poor	Annoying
1	Bad	Very annoying

C. Parameters influencing QoE

Another important factors that we need to consider are the values of video parameters like bit rate, video resolution, frame rate and codec, or network parameters like bandwidth, delay, jitter and packet loss. *Bit rate* represents the number of bits processed during one time unit. *Video resolution* is a size of video image an is measured in pixels, where the numbers represent horizontal and vertical resolution. *Frame rate* specify a frequency at which the streaming device produce images that are called frames. *Bandwidth* is defined as the amount of data per one time unit that are delivered over physical network topology, from the source to the destination. *Jitter* is best represented as an end to end delay between one packet to the next, within the same stream. *Packet loss* defines percentage of lost packets. *Delay* represent lapse of time or amount of time during some action is awaited. *Video codec* is a software used for encoding and decoding of a digital data stream.

III. STREAMING CONCEPTS

There are two major approaches how to stream video over the network. First approach uses standard Web server, e.g. Apache Http Server Project, and uses standard hypertext transfer protocol HTTP to deliver video and audio data to the client. The second approach uses separate streaming media server, e.g. Wowza Media Server. Both methods bypass old-fashioned download-and-play technology, where you have to download the whole file before playing it. Nowadays, there is a big demand on high quality for media content on the Internet. This new streaming technologies had to be designed to provide both quality and transfer time to satisfy Internet end-user.

A. Streaming with a Web Server

This approach is only a small evolutionary step from download-and-play model. Uncompressed audio and video are merged together to a single media file and then placed on standard Web server hard disk to be available for delivery on specific bandwidth. Next, a web page containing URL to this media file is placed on the same Web server. When request to this web page from a client is sent to the server, it launches client-side media player embedded in a web browser and a download of the media file to the client using http protocol will start. This can be achieved also by using media player and specify URL to the file to start this process. Application layer protocol http (in TCP/IP network model) on client-side will generate http request. Web server after receiving this request will start sending requested file with TCP protocol in context of http response. Unlike download-and-play model, client-side media player starts playing media file while the file is being downloaded. This is also called a progressive download. Only certain media file formats support this type of download. As we discussed earlier, this type of streaming uses http protocol that operates on top of the TCP. TCP retransmits lost packets and cannot assure that all resent packets will arrive at the client in time to be played in the media stream.

B. Streaming with a Streaming Media Server

This type of streaming is the true streaming. It uses dedicated streaming server to deliver data to client-side media player. This allows real-time broadcasting of live events and ability to control playback. To run own streaming server, there is a need to have licence of it. Some examples of such servers are Flash Media Server, Wowza Media Server, Windows Media Server, Darwin Media Server (QuickTime) and Real Media Server. Streaming servers can use variety of streaming protocols such as RTMP, RTSP and MMS that can handle transfer, communication between client and server.

IV. QUALITY OF VIDEO IN CONTEXT OF HTTP STREAMING

Because video data are transmitted over a communication network, the size of digital video data is an important issue in multimedia technology. Consequently, this data must be compressed before transmission in order to optimise the required bandwidth for the provision of a multimedia service. In a context of the http streaming technology, we focus on two main factors - video quality and bandwidth. It is necessary to tradeoff the network capacity against the perceptual video quality in order to come up with the optimal performance of a video service and an optimal use of underlying network infrastructure. Moreover, coded video streams are transmitted over network and thus exposed to channel errors and information loss. In this article, we introduce a tool that would help find this optimal performance for video service built on http streaming architecture.

A. Video quality

In terms of video quality, the parameters that we must consider are attributes like bit rate and video codec, video resolution and frame rate. Bit rate represents the number of bits processed during one time unit. Video resolution is a size of a video image measured in pixels, where the numbers represent horizontal and vertical resolution. Frame rate specify a frequency at which the streaming device produce images that are called frames. Video codec is software used for encoding and decoding of a digital data stream.

B. Bandwidth

Digitally compressed video is transferred over a packet-switched network. The physical transport can take place over a wire or wireless, where some transfer protocols like ATM or IP ensures the transport of the bitstream. The bitstream is transported in packets whose headers contain sequencing and timing information.

C. Network topology

It's obvious that each client can use different connection to the network and generally, video streaming is provided across Internet platform, thus every client will experience different bandwidth connection to the HTTP Server. HTTP streaming uses TCP unicast packets to each client. Our tool is constructed to monitor traffic and video parameters on each client thus providing a complex view what is the quality of service to the clients.

V. Introducing the Tool

This part of the work introduces design and implementation of the tool used to perform subjective assessment of video and audio quality based on gathering statistical data from respective measurements [Fig. 1]. It is the system that makes possible to assess video quality and streaming service as a whole on given architecture. The tool uses true streaming for delivering data with protocols as RTP and UDP and also video-on-demand principle with HTTP protocol. The tool is built on a variety of modern and powerful programming languages (C/C++, AJAX, Javascript, PHP, SQL), open-source and reliable applications (VLC Videolan Project, MySQL Server, Apache Server) and implemented with effective and high-performance standards and methods (multicast, RTP protocol). The tool represents an advantageous solution for gathering different client-side statistical data and subjective assessment data. This data are sent to remote database server and processed as needed. The combination of subjective and objective data makes possible to better analyze subject's assessment and to detect problems.

Fig. 1. Web interface of the presented system

A. Functional topology and components

The system consists of several components - http server, web page located on the server with specific client-side scripting code, media plug-in in clients' web browsers and database server. Http server provides web page with link to the video to be streamed. Web page contains specific functions that exploit functionality of media plug-in. Media player plug-in is primarily used to playback streamed video on client side. Player is embedded in a web browser and processes the video that is being downloaded. Media player plug-in has been modified to provide needed functionality - to provide real-time video statistical data such as input bitrate, read packets, state of playback, frames per second, etc. Web page contains code written in client-side web scripting language, so it runs on client side and handles the data gained from media plug-in. The gathered data can be sent to remote database where they are stored and third-party applications could access this data and evaluate them. The functional topology is shown in the [Fig. 2].

B. Adequate Parameter Choice

The tool monitors many parameters at client-side that help to find out the circumstances during assessment process and also depict characteristics of user playback. These parameters can be divided into four groups (Input, Video, Audio, and User parameters). The choice of these parameters must by adequate in order to carry objective information about circumstances and characteristics of user video sequence playback. Input parameters characterize the processing of incoming media stream (total read packets, read bytes, input bit rate, read packets rate, read bytes rate, corrupted blocks in demuxer, time of playing). Video parameters characterize the processing of video data (displayed pictures, lost pictures, resolution, frames per second). Audio parameters characterize the processing of audio data (decoded audio blocks, lost audio blocks) and finally user parameters characterize software and hardware of user (total memory, available memory, cpu frequency, operating system, browser, estimated connection speed.

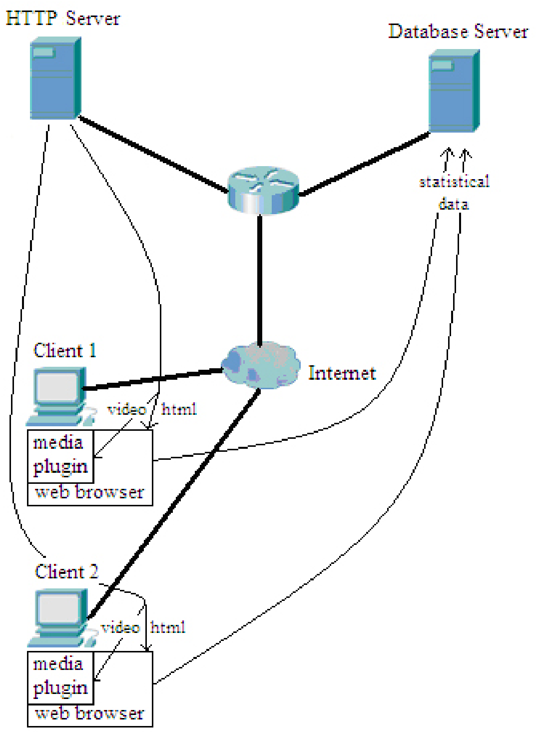

Fig. 2. Functional topology

C. Obtaining Media Sequence Information

The system stores characteristics for every multimedia sequence used for testing purposes. Sooner as the sequence is subject to assessment, it must be registered in the system and some information about it must be obtained. This information is automatically gathered using cgi script after the sequence has been successfully uploaded to the content server. The information includes general information about multimedia file (format, file size, overall bit rate, duration, bit rate mode, etc.), general information about video streams (format, bit rate, width, height, display aspect ratio, frame rate, standard, color space, chroma subsampling, bit depth, scan type, compression mode, etc.), general information about audio streams (format, bit rate, channels, sampling rate, bit depth, compression mode, duration, etc.) and general information about text streams (format, video delay, etc.). This information is valuable to identify sequences' needs to streaming service, structure and restrictions. Obtaining and storing of this information is integrated to the system what increases simplicity and flexibility.

D. Realization of Subjective Assessment

1) *Creation of data stream* - in the case of true streaming administrator starts for given sequence multicast streaming to network with protocol RTP or UDP. In the case of video-on-demand, for every request from user the separate unicast HTTP data stream is produced.
2) *Creation of playback instance* - user requests data stream (multicast or unicast) using web browser multimedia plug-in.
3) *Creation of user profile* - for every playback instance a new user profile is created - information about user hardware and software and estimated connection speed is obtained.
4) *Gathering real-time statistical data during playback* - gathering data in the background about incoming played stream.
5) *Multimedia sequence assessment* - - user can at any time assess played sequence. Three aspects are assessed - video quality, audio quality and playback quality, using five grade numeric rating scale (1 - Excellent, 2 - Good, 3 - Fair, 4 - Poor, and 5 - Bad).
6) *Sending data to database server* - when all three aspects are rated, the data are automatically sent to remote database using AJAX technology.
7) *Analysis of gathered data* - data is gathered in logical hierarchy and interpretation of results is left to administrator.

E. Implementation of gathering client-side statistical data

Gathering statistical data is performed by web browser and Javascript. This concept is used for its simplicity, it is not practical to ballast user with installation and maintaining of other applications. Data represents input data for local application embedded into web browser. The question is, how can one get access to this data in web browser using Javascript. Normally, it is restricted to access computer local data because of security. But the tool exploits embedded plug-in (VLC Multimedia Plug-in) to get access. This extended functionality has been simply added because VLC Multimedia Plug-in is open source and can be modified as needed. To access data, the tool calls Javascript API of the plug-in. This concept is really transparent, simple and powerful. Extended functionality represents creation of new Javascript object - Stats and Client besides others. The example of using these objects in web page is as shown below.

```
< scriptlanguage = "Javascript" >
var vlc = document.getElementById("vlc");
var readBytes = vlc.stats.readBytes;
var readPackets = vlc.stats.readPackets;
var inputBitrate = vlc.stats.inputBitrate * 8000
var displayedPictures =
vlc.stats.displayedPictures;
var lostPictures = vlc.stats.lostPictures;
var decodedVideo = vlc.stats.decodedVideo;
var decodedAudio = vlc.stats.decodedAudio;
var totalRAM = vlc.client.totalRAM;
var availRAM = vlc.client.availRAM;
var cpuSpeed = vlc.client.cpuSpeed;
< /script >
```

VI. Related Work

A number of studies have explored the idea of predicting user experience. The most interesting approaches combine the objective measurements with the empirical experiments gaining subjective ratings such as the MOS [4] to get user experience estimation. There is a lack of approaches that build a prediction models on this basis. Some, like [5] and [6], correlate measurements on both the sender and receiver sides. Others, like [7] and [8], use the Emodel [9], an objective mechanism for assessing audio quality using transmission parameters. An alternate approach is to utilize application-layer objective metrics, taken at the clients machine through an instrumented media player application [8], [10], [11], [12]. These approaches allow one to take measurements without requiring the users participation, providing a more accurate assessment of the user experience, but do not provide prediction models.

VII. Conclusion

Presented approach is based on the analysis of user experience sensitivity on a changes of videostreaming quality attributes. Using this tool, service providers take advantage of high performance tool to gather real-time client-side streaming video statistical data. Data are retrieved and processed at client side, so the streaming server is not unnecessary stressed. This data can be consequently sent to remote database where they are stored and linked to particular client. Third-party applications can access this data and evaluate them. This helps to identify and solve problems with streaming service and improve quality of service. Presented tool is built on open source software, which is flexible, scalable and still improving. In future, it can be used for testing and further educational purposes.

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