Review on Smart Video Streaming Schemes for Cloud Based E-Learning

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Abstract This study is an initial effort to determine the best way to deliver rich educational data such as video materials over cloud computing environment. Cloud computing has been widely applied in various fields of business and private sector to simplify complexity of data management and networking. It also drew attention in educational institutions to improve the existing services of e-learning by adopting cloud technology. However, delivering rich educational content within a mesh network commonly influenced by bandwidth, jitter and loss of data which sometimes significantly reduces its quality at end user side. In dealing with the issues, several smart video schemes have been proposed to improve video streaming quality. The approaches look the issue from different perspectives and use variety of methods to produce the so called smart video streaming scheme as mentioned in literature. This study aims to explore state of the art on smart video streaming schemes and organize them into particular groups. It is expected that the effort will not only beneficial for next steps in the research but will also help other readers better understand advancement in the field as well as indentifying particular gaps where other researchers could contribute in the future.

Keywords Video streaming · Smart video streaming scheme · Cloud computing

1 Introduction

Video streaming is moving pictures that is constantly received by and presented to an end-user while being delivered by a provider. Its verb form, "to stream", refers to the process of delivering media in this manner; the term refers to the delivery method of the medium rather than the medium itself [1].

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Basically, video streaming technique compresses and buffers the video first before sending it to end users in small piece of packet data. End users will be beneficial by obtaining series of video packets that can directly played before receiving video pakets completely.

After capturing the live video by using capture device such as a video camera, web cam, or a video feed from a switcher, then the video packets are encoded into streaming by using particular codec based software. Codec is technology to compress video files which consists of two components; an encoder to compress the video file and store it in the server and a decoder which decodes the file when played by the end user.

Once whole video packets fully encoded, the next step goes to storing them in the streaming video server. The server is typically a special server which is designed to collect video feed and re-distribute it again in real-time streaming video. Application server is applied in this stage to manage how the video should be consumed later by the end users. Finally, end user may access the video streaming from the server directly.

Considering its features and advantages, video streaming has been then adopted in many areas such as education, transportation, business, and others. Hartsell and Yuan report various applications of video streaming to deliver interactive and fruitful educational materials online [2]. Advancements in cloud computing technologies also attract e-learning with video streaming application as proposed by Al-Zoube [3] although its effectiveness strongly criticized by Pocatilu et al. [4] who assessed several e-learning initiatives on the cloud.

Streaming technology also benefits current transportation systems through enhancing quality of monitoring systems that could improve public transportation services. Barton and Simon [5] present a study of Seoul Metropolitan Rapid Transit Corporation (SMRT) with real-time video streaming surveillance system that has given operators more ability to keep an eye on all trains and stations which eventually increases public transportation safety. In 2012, Chang and Hsieh [6] investigate the applicability of video streaming proxy to tackle with speed train problems in Taiwan.

However, huge bandwidth consumption, jitter problems and high possibilities of loss of important data are serious gaps that need effective solution in delivering adequate quality of video streaming to satisfy user needs. Compromising high consumption and limited bandwidth issues are among attractive research as can be seen in literature particularly in the specific area called intelligent video streaming. Intelligent video streaming scheme is a logical effort to make video data smart enough in serving various clients conditions in mesh network such as the Internet in order to deliver adequate quality of video streaming to different users.

This paper aims to present a survey on several smart video streaming schemes as a foundation for next research of developing cloud based video learning. The rest of this paper is structured as follows. Section 2 describes basic theory of video streaming. Subsequently, current schemes on smart video streaming techniques are elaborated in Sect. 3. Finally, conclusion and future research direction are given in the last part of the paper.

2 Basic Video Streaming Technologies

The following are fundamental theory underlying video streaming technology. It describes standard protocols, compression techniques for video package as well as limitations or obstacles in extending video streaming services over network media.

2.1 Video Streaming Protocols

Generally, protocol consists of specific rules that should be followed in order to make use of a particular technology. In terms of streaming technology, a set of protocol are used to carry message in the form of video packets and enable communication between parties that require to playing them. The following are several protocols commonly used in streaming technology.

Real Time Transport Protocol (RTP) is UDP packet format which is a set of conventions that provides end to end network transport functions. The protocol suitable for any video streaming applications for transmitting real time data, such as audio, video or simulation data, over multicast or unicast network services [7].

Session Description Protocol (SDP) is protocol based on a media description format. The protocol is intended for describing multimedia sessions for the purposes of session announcement, session invitation, and other forms of multimedia session initiation [8].

Hypertext Transfer Protocol (HTTP) is an application level protocol for distributed, collaborative, hypermedia information systems. It is a generic, stateless, object oriented protocol that can be used for many tasks, such as name servers and distributed object management systems, through extension of its request methods [7].

Real Time Streaming Protocol (RTSP) is an application level protocol for control over the delivery of data with real time properties. RTSP provides an extensible framework to enable controlled, on demand delivery of real time data, such as audio and video, using the Transmission Control Protocol (TCP) or the User Data Protocol.

Realtime Control Protocol (RTCP) is a specific protocol that works in conjunction with RTP for packet control purposes. RTCP control packets are periodically transmitted by each participant in an RTP session to all other participants. RTCP is used to control performance and for diagnostic purposes [8].

2.2 Video Compression Technology

Directly trasmitting raw video packet over the network is not an efficient option since it eventually will cause network jamming and media transmission problems. Therefore, in order to effectively deliver it in networks media, video package must

Table 1 Video compression parameters

	Uncompressed SD video source	SD broadcast television	ADSL or cable modem	Analog modem
Frame size	720 × 480	720 × 480	192 × 144	160 × 120
Frame rate	30	30	15	5
Color sampling	4:2:2	4:2:0	YUV12	YUV12
Video source rate	166 Mbit/s			
Uncompressed data rate after scaling		124 Mbit/s	5 Mbit/s	1.15 Mbit/s
Target data rate		4 Mbit/s	500 kbit/s	35 kbit/s
Total data reduction to meet target rate		40:1	330:1	4700:1
Scaled data rate		1:1.33	1:33	1:144
Compression from scaled rate to target rate		30:1	10:1	30:1

undergo a number of compression procedures. Video compression is a technology to reduce size of actual video into smaller one without the expense of video quality itself. Uncompressed video source has frame size of 720 × 480, after compression it becomes 192 × 144 for ADSL or cable modem and finally compressed down to 160 × 120 for analog modem [9] (Table 1).

The table shows several parameters of video compression such as such as frame rate, color sampling, video source rate, uncompressed data rate after scaling, and target data rate. For each different media, the value of total data reduction to meet target rate, scaled rate and compression from scale are presented. In addition, total data reduction to meet target rate, scaled rate and compression from scale are given [10].

Instead of many benefits of video streaming, it also has limitations in terms of guaranteeing good quality results at end users particularly in mesh network such as the Internet. As the media transmission quality varies, video transmission rate needs to be adapted accordingly. However, it is uneasy to maintain the quality of video streaming in such conditions. Commonly, it suffers from three main problems called bandwidth limitation, loss of data and jitter [9, 11].

3 Intelligent Video Streaming Schemes

Intelligent video streaming scheme is a logical approach to make video package intelligent enough to be adaptive with conditions as mentioned previously by changing various aspects of the video package In this case, all schemes are categorized according to their similarities in terms of their objectives and basic characteristics as presented below.

3.1 Video Adaptation Schemes

Video adaptation is considered the basic technique used for video streaming to keep the quality of video being transmitted according to the capability of data sender to deal with instable network conditions. This scheme develops flexible media streaming to address the problem of serving heterogeneous clients with adaptive video quality.

Simulcast is the earliest approach in this scheme which was widely used method for video adaptation [12]. It encodes single video source into multiple independent streams that has different bitrate and quality suitable for different level of clients. At client side, particular bitrate of encoded video is chosen according to its access bandwidth [13].

New smart architecture for video streaming called video transcoding is introduced [14]. It can be done by adapting the flow with the rate constraints, and/or user preferences in scale and spatial-temporal distortion [15]. Another transcoding approach for delivering video streaming within wireless environment is proposed in [16]. The algorithm takes into account structure of video streaming and carefully tradeoff spatial and temporal distortions to enable good video quality to the end users [16, 17]. However, it only effective to serve small different bit-rates of video [18].

Intelligent Prioritized Adaptive Scheme (iPAS) is another one for adapting the encoding and transmission bitrates of video streaming based on stream priority and network bandwidth resources which are estimated by using bandwidth estimation technique. bandwidth estimation technique [19].

3.2 Scalable Streaming Schemes

Advancement in media transmission, enable video data to be streamed in network environment where many users receive video at their end. However, source adaptation schemes could not satisfy these requirements. In a broadcast or multicast environment, since there are large variations in adaptation need among receivers, performing coding at every edge is not effective solution, thus scalable streaming scheme is more appropriate than source adaptation scheme.

Fine Granularity Scalability or FGS for spatial quality adaptation is among the earliest algorithm to scalable video streaming [16, 20]. It is then improved by Ohm [21] who introduced Motion Compensated Temporal Filtering (MCTF) algorithm for temporal scalability of video streaming.

Ohm argues that computational costs involved in scalable are robust and typically much smaller than the transcoding case since it only need once coding process, then the bit stream can be extracted and repacketized to fit different media condition with no need for many transcoding processes [21]. Another advantage of scalable streaming is truncating bit stream might be done at almost every points, and still can be decoded with reconstruction quality corresponding to number of bits recovered [22].

In 2006, an smart application of scalable streaming was enhanced with Self-tuning Neuro-Fuzzy (SNF) to enable MPEG video data over the Bluetooth channel [23]. Likewise, Kazemian [10] demonstrates this scheme combined with traffic-shaping buffer based on Neural-Fuzzy algorithm to enable video transmission over IEEE 802,15,4 or ZigBee network which has many restrictions such as low power, low cost, low complexity wireless standards, and very limited bandwidth support.

Another approach is called Multiple Description Coding (MDC) [24], in which a video is encoded in two or more independently decodable layers. The decoded video quality is proportional to the number of layers decoded. Nevertheless, scalable coding techniques are still not in widespread use. It is argued by Mou et al. [18] that the main reason behind it is for a few targeted bit-rates, coding individual streams yields still better quality than coding multiple layers.

3.3 Video Summarization Schemes

More smart solution compare to previous schemes is called video summarization schemes [25]. This scheme deals with the issue on how to manipulate the large quantity of video streaming data particularly in network environment.

Video summarization scheme applies smart algorithm for analysis, structuring, and summarizing video content according to various user preferences in viewing the video [26].

The most popular type of video summary is the pictorial summary. It has three access levels making easier the search for video sequences. The first access level enables users to obtain full access for the whole archive. The second access level is developed to help users browsing video archive according to video summaries. The third access level accelerates the archive browsing by adding an indexing subsystem, which operates on video summaries [27].

This type of smart video streaming scheme is widely deployed in current video streaming delivery which sometimes requires personalization according to user preferences such as sport games [28]. Other type of smart video summarization is shown in [22] by formulating particular algorithm to enhance multi-user video communication solution with better efficiency in resource utilization and better overall received video quality.

3.4   Secure Media Streaming Schemes

In contrast to previous schemes, the final type of scheme focuses on adding security parameters to enhance smart video streaming. Secure scalable streaming (SSS Framework) is considered as the first security scheme proposed by Wee and Apostolopoulos [29]. The framework supports end-to-end delivery of encrypted media content while enabling adaptive streaming and transcoding to be performed at intermediate, possibly untrusted, nodes without requiring decryption and therefore preserving the end-to-end security. However, this method does not provide authentication mechanisms at sender side, thus it vulnerable to malicious attacks from this point of view [18].

Another approach is called the ARMS system proposed by Venkatramani et al. [30]. This approach enables secure and adaptive rich media streaming to a large-scale, heterogeneous client population within untrusted servers. In 2004, Secure Real Time Transport Protocol (SRTP) was developed to provide confidentiality, message authentication, and replay protection as basic security services required for secure video streaming [7, 18]. Chiariglione et al. [31] propose a MPEG standard aiming at standardizing the format for distribution of governed digital content. It has two main objectives, firstly to protect rights of holders and secondly solve the interoperability issue that is worsened by the many existing proprietary DRM systems. The standard governs how to deliver encrypted content and performing mutual authentication between devices involved and integrity authentication of governed content. Yet, adaptation and other flexible handlings of multimedia are sacrificed which makes it difficult for wider adoption.

4   Summary

In this paper, several smart video streaming schemes have been reviewed and classified into four main groups according to their characteristics and objectives.

The first category is called Video Adaptation Scheme. It is a smart algorithm applied to video streaming to keep the quality of video being transmitted according to the various and instable bandwidth conditions. Limitation of the scheme is seen when it applied at large variety of client in network with large different bit-rates.

Scalable Streaming Scheme is the second category of smart video streaming. They are grouped based on similar objectives they have in maintaining the quality of video streaming in network environment where many users receive video according to their characteristics.

The next category of smart video streming is called Video Summarization Scheme. They are considered a smarter solution compare to previous schemes. This third category of scheme give ability to identify large quantity of video streaming data in heterogonous network environment.

Final category is Secure Streaming Scheme. It offers unique approach to previous schemes with security in mind. Using various approaches, smart video schemes in this category provide better security and privacy mechanisms of video streaming at the expense of adaptability or scalability.

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