Review on Intelligent Video Streaming Schemes for Cloud Computing

Irfan Syamsuddin

Abstract—**Video streaming has emerged as an important tool for business, education, transportation and other fields. This study acts as a preliminary study on delivering video streaming within a mesh network such as cloud computing infrastructure. In this situation, bandwidth, jitter and loss of data are still considered as serious issues to be solved with respect to great number of end users with various network characteristics and with a goal to keep the video at appropriate quality. Several intelligent schemes to improve video streaming services have been proposed by researchers through different approaches. This study aims to explore state of the art in intelligent video streaming schemes as a foundation for future applications of video streaming solution that is adaptive with the cloud infrastructure condition.**

Keywords—*Video streaming;networking; intelligent algorithm; survey*

I. 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].

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 though obtaining series of video packets that can directly played before complete video received.

Figure 1 shows steps from developing to streaming video to client terminal. It starts from capturing the live video by using capture device such as a video camera, web cam, or a video feed from a switcher. Next step is encoding the video 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 is work to decode the file when played by the end user.

After all videos 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 in the form of streamed video. Application server is applied in this stage to manage how the video to be consumed later by the end users. Finally, end user may access the video streaming from the server.

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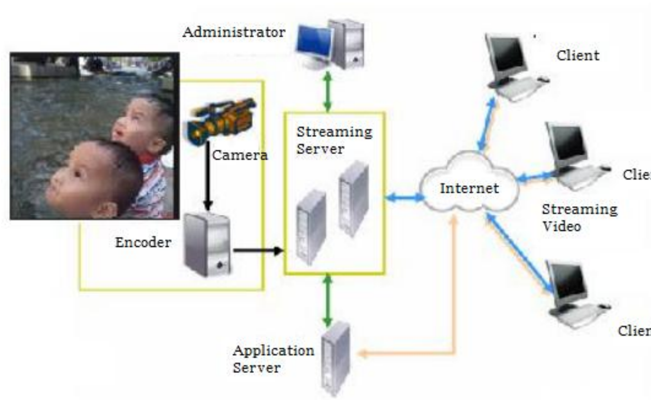

Fig. 1. Steps for developing video streaming content.

Video streaming has been applied in several areas such as education, transportation, business, etc. 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 based 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 since it offers better quality of monitoring systems. 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 and loss of important data are serious gaps that need effective solution in delivering adequate quality of video streaming to different users. Compromising high consumption and limited bandwidth issues is an attractive research as can be seen in literature particularly in the area of intelligent video streaming to make video data smart enough in serving various clients conditions in mesh network such as the Internet are serious gaps that need effective solution in delivering adequate quality of video streaming to different users. Compromising high consumption and limited bandwidth issues is an attractive research as can be seen in academic literature particularly in the area of intelligent video streaming to make video data smart enough in serving various clients conditions in mesh network such as the Internet.

This paper aims to provide a survey on several intelligent video streaming schemes as a foundation for further research steps in featuring e-learning with video streaming features in heterogonous network.

The rest of this paper is structured as follows. Section 2 describes basic theory of video streaming. Subsequently, current schemes on intelligent video streaming techniques are elaborated in section 3. Finally, conclusion and future research direction are given in the last part of the paper.

II. VIDEO STREAMING: TECHNOLOGY AND LIMITATIONS

A. Protocols Used in Streaming Technology

Protocols are specific rules that should be followed in order to make use of a particular technology. In 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 [7,8]:

1) Session Description Protocol (SDP)

A media description format intended for describing multimedia sessions for the purposes of session announcement, session invitation, and other forms of multimedia session initiation.

2) Real Time Transport Protocol (RTP)

A UDP packet format and set of conventions that provides end to end network transport functions suitable for applications transmitting real time data, such as audio, video or simulation data, over multicast or unicast network services.

3) Realtime Control Protocol (RTCP)

RTCP is the control protocol that works in conjunction with RTP. 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.

4) Hypertext Transfer Protocol (HTTP)

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.

5) Real Time Streaming Protocol (RTSP)

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 (UDP).

B. Video Compression Technology

In order to deliver particular video in networks media, it must undergo compression steps. Video compression is a technology to reduce size of actual video into smaller one without the expense of video quality itself. Austerberry [8] describes different compression technologies for digital video through the following visualizes.

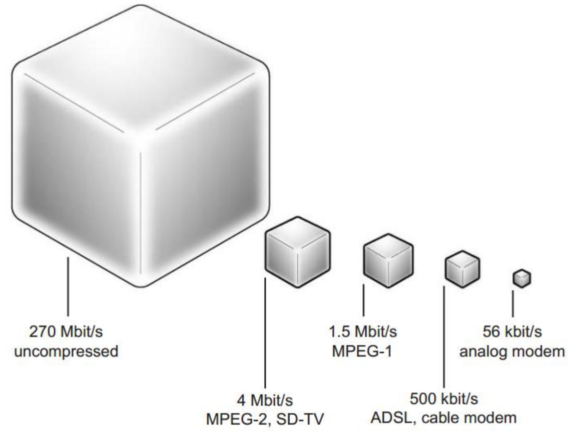

Fig. 2. Video size before and after compression. [8]

Uncompressed video source has frame size of 720x480, after compression it becomes 192x144 for ADSL or cable modem and finally compressed down to 160x120 for analog modem.

TABLE I 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

In table 1, several parameters of video compression such as such as frame rate, color sampling, video source rate, uncompressed data rate after scaling, target data rate are presented. It also mentions total data reduction to meet target rate, scaled rate and compression from scale.

C. Limitations

Instead of many compelling 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. Various video streaming transmission problems might be categorized into the following three main issues [9] [10] [11]:

1) Bandwidth

The bandwidth available between transmitter and receiver of video data in the network is usually unknown and time-varying. In the case of sender transmits data faster than the available bandwidth, a congestion will occur, data packets are lost, and finally video quality will drop. On the other hand, when the sender transmits slower than the available bandwidth then the receiver produces sub-optimal video quality. Therefore, the challenge is how to estimate the available bandwidth and match the transmitted video bit rate to the available bandwidth.

2) Loss of data.

Due to various encoding processes and different quality of network condition, particular packet video data are dropped in the transmission randomly. This is the major hindrance in effective multimedia streaming of loss of data in the network.

A number of different types of losses may occur, depending on the particular network under consideration. In order to limit the impact of loss, error control is applied to video streaming system such as forward error correction, retransmissions, error concealment, and error-resilient video coding.

3) Jitter

Jitter happens to video when a packet experiences fluctuation in end-to-end delay from packet to packet. This variation is then referred to as delay jitter. This problem occurs because the receiver must receive/decode/display frames at a constant rate, and any late frames resulting from the delay jitter can produce problems in the reconstructed video. This problem is typically addressed by including a playout buffer at the receiver.

Unfortunately, while the playout buffer can compensate for the delay jitter, it also results another kind of delay. Therefore, dealing jitter still considered as challenging issue in video streaming technology.

Based on the three main problems above, video streaming requires particular improvements in order to keep video quality at acceptable level. One of available solutions is called intelligent video streaming scheme.

Intelligent video streaming scheme is an approach to make video package smart enough to maintain various aspects of the data such as bit rate, bit stream encoding and decoding, and distortion rate such through a set of algorithms to make users with different network conditions able to obtain appropriate video quality at their ends.

III. Intelligent Video Streaming Schemes

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Intelligent video streaming scheme is a logical approach to make video package intelligent enough to adaptive with the conditions by changing various aspects of the video package such as bit rate, bit stream encoding and decoding, distortion rate, and so on through particular algorithms to guarantee video quality at end users. Several schemes on intelligent video streaming mechanism are discussed as follows:

A. Video Adaptation Schemes

Video adaptation is a 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 condition. This adaptive scheme develops flexible media streaming to address the problem of serving heterogeneous clients with adaptive video quality.

Simulcast [12] is considered as the earliest approach of this scheme which was widely used method for video adaptation. 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].

In [14], a new intelligent architecture for video streaming called video transcoding is introduced. Applying transcoding to video streaming can be done adapting the flow with the rate constraints, and/or user preferences in scale and spatial-temporal distortion. The simplest transcoding technique is through format conversion, reduction of bit rate for wireless delivery or in the form of reducing the size to fit the bandwidth or end user terminal [15].

Another transcoding approach for delivering video streaming within wireless environment is proposed by [16]. Transcoding technique take into account content or structure of video streaming and carefully tradeoff spatial and temporal distortions to enable good video quality to the end users [16,17].

However, this scheme is not suitable to be used at large variety of client in network as it can only serve several different video streams with small different bit-rates [18].

More recently, Yuan, et.al [19] introduce the intelligent Prioritized Adaptive Scheme (iPAS) 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.

B. 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 that truncating bit stream might be done at almost every point, and still can be decoded with reconstruction quality corresponding to number of bits recovered [22].

In 2006, an intelligent 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 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.

C. Video Summarization Schemes

More intelligent solution compares 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 intelligent 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 provided to help users browsing video archive according to video summaries. The third access level that accelerates the archive browsing by adding an indexing subsystem, which operates on video summaries [27].

This type of intelligent 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 intelligent 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.

D. Secure Media Streaming Schemes

Unlike the previously mentioned schemes, this 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 mechanism at sender side, thus it vulnerable to malicious attacks [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 wide adoption.

IV. Conclusion And Future Research Direction

In this paper, we have reviewed several intelligent video streaming schemes and grouped them into four main schemes as follows.

Video adaptation scheme is the first category which is an intelligent algorithm applied to video streaming to keep the quality of video being transmitted according to the various and instable bandwidth condition. Limitation of the scheme is obvious when it applied at large variety of client in network with large different bit-rates.

Scalable streaming scheme is the second type of intelligent video streaming scheme that is capable in maintaining the quality of video streaming in network environment where many users receive video according to their characteristics. However, it still does not guarantee delay jitter in heterogonous network.

Video summarization scheme is more intelligent solution compare to previous schemes. This scheme can identify large quantity of video streaming data in heterogonous network environment. The main issue of this scheme is high computational cost it has.

Final scheme is called secure streaming scheme. It offers unique approach to previous schemes with security in mind. The main problem which causes the scheme hardly adopted is that it does not provide flexible handlings of video streaming data such as adaptation or scalability.

In the future, results from this study can be improved in several ways such as QoS assessment of several schemes in simulation environment and applying particular intelligent algorithms to video streaming in e-learning management systems.

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