A Novel Framework to Select Intelligent Video Streaming Scheme for Learning Software as a Service

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Abstract **–Cloud computing offers many benefits for government, business and educational institutions as exemplified in many cases. Options to deliver video streaming contents for educational purposes over cloud computing infrastructures are highlighted in this study. In such case, parameters that affect video quality directly or indirectly must be taken into account such as bandwidth, jitter and loss of data. Currently, several intelligent schemes to improve video streaming services have been proposed by researchers through different approaches. This study aims to propose a novel framework to select appropriate intelligent video streaming schemes for efficiently delivering educational video contents for Learning Software as a Service (LSaaS).**

Keywords: Cloud computing, video streaming, intelligent video streaming scheme, decision making, Software as a Service

1. INTRODUCTION

Video streaming technologies have been applied to deliver educational contents through e-learning management systems over client server based infrastructures. However, high cost of ICT infrastructure development and maintenance and also lack of automatic expandable service in case of high users demand and many others limit the capability of current e-learning systems to broaden its service [1].

On the other hand, cloud computing seems to promise a simpler and more flexible solution to tackle the issue since data, information, hardware resources, and software applications are available on demand via the internet (cloud) and can be accessed through web browser as a utility service, anytime and anywhere [1]. Its on demand service and renting business systems are argued to be very promising to extend current limitation of e-learning systems by developing Learning Software as a Service (LSaaS).

In order to improve efficiency of video streaming delivery in the network, several intelligent video streaming schemes are proposed in different approaches as mentioned in related academic literature. This study aims to elaborate the schemes and further propose a multi criteria decision making model to selection intelligent video streaming scheme to be applied in cloud computing environment.

2. BASIC VIDEO STREAMING TECHNOLOGIES

Basically, video data should undergo two steps in order to deliver it in network media. First must undergo video compression process. Video compression is a technology to reduce size of actual video into smaller one without the expense of video quality itself. Austerberry describes different compression technologies for digital video through the following visualizes [2].

Table 1. Comparison between IPv4 and IPv6

	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

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. As can be seen 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.

The second step is using a set of protocol to video packets and enables communication between parties that require to playing them. Protocols used for streaming technology are as follows Session Description Protocol (SDP), Real Time Transport Protocol (RTP), Realtime Control Protocol (RTCP), Hypertext Transfer Protocol (HTTP), Real Time Streaming Protocol (RTSP) [2][3].

3. Intelligent Video Streaming Schemes

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 are influenced by bandwidth limit [4], loss of data [5] and jitter [6] as common problems in delivering streaming video packets within network.

Intelligent video streaming scheme is solution for the issue which is basically a logical algorithm approach to make video packets intelligent enough and adaptive with the unfriendly network conditions. Various intelligent video streaming schemes (IVSS) mentioned in literature might be categorized into four main groups 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 [7] 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 [8].

In [9], 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 [10].

Another transcoding approach for delivering video streaming within wireless environment is proposed by [11]. 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 [11,12]. 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 [13].

More recently, Yuan, et.al [14] 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.

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 [11][15]. It is then improved by Ohm [16] 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 [16].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 [17].

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 [18]. Likewise, Kazemian [5] 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) [19], 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 [13] 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 compare to previous schemes is called video summarization schemes [20]. 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 [21].

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 [22].

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 [23].

Another type of intelligent video summarization is shown in [17] 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 [24]. 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 [13].

Another approach is called the ARMS system proposed by Venkatramani, et.al [25]. 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 [3][13].

Chiariglione, et.al [26] 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.

4. SELECTION METHOD

The issue of selecting appropriate intelligent video streaming schemes as mentioned in section 3 falls into multi criteria decision making (MCDM) problem. Refer to our previous work [27], the selection framework combines Analytic Hierarchy Process [28] and ISO 9126 Software Engineering [29] to probe the problem highlighted in this paper.

Analytic Hierarchy Process is preferred as methodology considering its effectiveness and widely proven in more than thousand case studies in different fields [30]. Moreover, the availability of official AHP software namely Expert Choice is another advantage of using the method. Similarly, ISO 9126 is an international standard for software engineering requirement which is widely applied to deal with software selection and evaluation [27].

Figure 1 depicts the framework hierarchy according to AHP method which consists of four layers. First layer is the goal of Selecting IVSS (Intelligent Video Streaming Scheme), the second and the third layer are criteria and sub criteria of selection based on ISO 9126, and finally the last layer are alternatives of available IVSS.

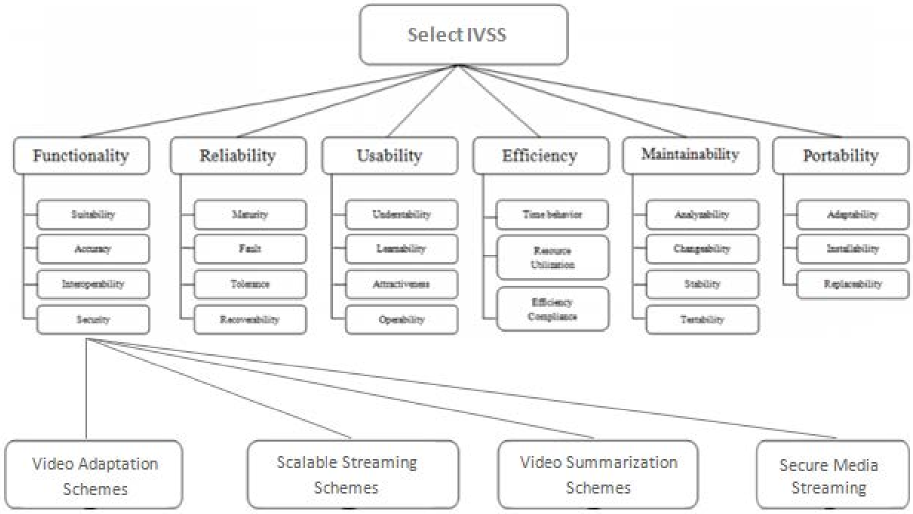

Fig 1. Framework of selecting intelligent video streaming software (IVSS) based on AHP

An individual or a group of experts in the field are required to be respondents to make proper selection of the existing alternatives based on AHP's pairwise judgment of 1-9 scales. This will be performed as further step of this study in order to show how the framework works and finally derives the final selection.

5. Conclusion and Future Work

Cloud computing has many potential benefits that could respond limitations of current traditional information technology infrastructures and applications. One of its prospective applications is delivering video streaming for education over cloud computing infrastructure in the form of Learning Software as a Service (LSaaS). Considering challenges in delivering video education over cloud infrastructure, a proper intelligent video streaming scheme (IVSS) must be applied. Current academic literature shows various intelligent schemes for video streaming are proposed through different approaches which essentially can be categorized in four main types of IVSS. The four categories of IVSS serve as candidate to be selected for video streaming application for LSaaS.

In this paper, a novel framework to select one of several intelligent video streaming schemes for LSaaS is proposed. The framework is based on Analytic Hierarchy Process (AHP) method combined with ISO 9126 to develop selection hierarchy in four layers.

In the future, this study will be improved by presenting a working example of how the decision process is performed according to AHP four steps of calculations until the proper intelligent video streaming schemes finally selected.

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