Decision Making Analysis of Video Streaming Algorithm for Private Cloud Computing Infrastructure

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Article Info	ABSTRACT
	The issue on how to effectively deliver video streaming contents over cloud computing infrastructures is tackled in this study. Basically, quality of service of video streaming is strongly influenced by bandwidth, jitter and data loss problems. A number of intelligent video streaming algorithms are proposed by using different techniques to deal with such issues. This study aims to propose and demonstrate a novel decision making analysis which combines ISO 9126 (international standard for software engineering) and Analytic Hierarchy Process to help experts selecting the best video streaming algorithm for the case of private cloud computing infrastructure. The given case study concluded that Scalable Streaming algorithm is the best algorithm to be implemented for delivering high quality of service of video streaming over the private cloud computing infrastructure.

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1. INTRODUCTION

Video streaming technologies have been applied to deliver multimedia contents over client server based infrastructures. Nonetheless, issues such as high maintenance cost of ICT infrastructure and lack of automatic upgrading services are among many issues to broaden e-services in client server mode as found in government, education and business [1]. Cloud computing with its advantages such as simplicity in hardware management as well as flexibility in handling increasing users demand, seems to provide one stop solution to all current e-services issues [2]. Delivering video streaming contents of e-services over cloud computing infrastructures is an amerging trend that offers many benefits to dynamic needs by different users. Although, applying video streaming service in the form of private cloud infrastructure shows better performance and lower implementation cost [3] than that in the form of client server infrastructure, its quality of service still affected by jitter, loss and delay [2].

To improve quality of service of the video streaming, several intelligent video streaming algorithms have been proposed. Several logical approaches are introduced to improve efficiency of video streaming delivery in the network. Currently, there are a number of intelligent video streaming algorithms found in the literature. While, this provides many options for organization to select and test, without a comprehensive decision framework, such trial-error selection will eventually resulting in high cost and inefficiency.

This study aims to tackle the issue of selecting the best intelligent video streaming algorithms for private cloud computing. An integration of Analytic Hierarchy Process and ISO 9126 (international standard for software engineering) is proposed in this study as a novel decision analysis. The rest of paper is organized as follows. After the introductory section, literature review on current intelligent video streaming algorithm is

presented in section 2. Section 3 describes methodology applied in the study. The analysis is then exemplified in section 4. Finally, section 5 provides overall summary of the study.

2. LITERATURE REVIEW

Basically video packets should undergo two stages before being passed in the network. The first stage is called compression process and the second one is streaming process. While data compression reduces size of actual video into smaller one without the expense of video quality itself, streaming procedures enable users to play video step by step without having to obtain the whole data first [2]. Although it has many advantages, quality of service (QoS) sometimes being questioned. Lack of QoS experienced by end users particularly occurs in mesh network such as the Internet. Basically QoS of video streaming is influenced by bandwidth limit, loss of data and jitter [5] [6] [7].

To tackle the issue, various intelligent video streaming algorithms have been introduced. The main aim of the algorithm is to make video packets intelligent enough and adaptive with the unfriendly network conditions. At the end by applying the intelligent algorithm, quality of video streaming can be enhanced. Previous study [4] suggested that intelligent video streaming algorithms can be classified into four main groups as follows.

2.1. Video Adaptation Algorithm

Video Adaptation algorithm is considered as the basic technique used for video streaming to maintain video quality according to the capability of data sender and it deals primarily with instable network condition. This adaptive scheme develops flexible media streaming to address the problem of serving heterogeneous clients with adaptive video quality.

Simulcast [8] is among the earliest approach of video adaptation. It encodes single video source into multiple independent streams differently and at client side, particular bitrate of encoded video is chosen according to its access bandwidth [9]. Video transcoding [10] is another intelligent scheme that adapts the video streaming according to the flow rate constraints of user preferences. Formatting video conversion while reducing bit rate of the video or dropping video size to fit the bandwidth of end user are main techniques applied in this algorithm [11].

In mesh network environment such as wireless [12], another adaptation algorithm called transcoding technique offers flexibility to carefully tradeoff spatial and temporal distortions to enable good video quality to the end users [12] [13]. However, this scheme has serious limitation for large variety of clients in network [14]. Then, Yuan, et.al [15] introduce the intelligent Prioritized Adaptive Scheme (iPAS) as an advanced algorithm for adapting the encoding and transmission by estimating bandwidth usage within different network situations.

2.2. Scalable Streaming Algorithm

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 [12] [16]. The algorithm was then improved by Ohm [17] who introduced Motion Compensated Temporal Filtering (MCTF) algorithm. Another advantage of this algorithm is that truncating bit stream can be done at almost every point [18].

Self-tuning Neuro-Fuzzy (SNF) is proposed in [19] to enable MPEG video data over the Bluetooth channel. Likewise, Kazemian [6] demonstrates this scheme combined with traffic-shaping buffer based on Neural-Fuzzy algorithm to enable video transmission with low power, low cost, low complexity wireless standards, and very limited bandwidth support. In addition, Multiple Description Coding (MDC) [20] is another algorithm which encode video into two or more independently decodable layers.

2.3. Video Summarization Algorithm

Video Summarization algorithm is proposed as a solution to the weaknesses of the previous two algorithms [21]. 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 [22].

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 [23]. It is widely deployed with personalization capabilities according to user preferences such as sport games [24]. Other type of intelligent video summarization is introduced by Li, et.al [18]. It enhances multi-user video communication solution with better efficiency in resource utilization and promises better overall received video quality.

2.4. Secure Media Streaming Algorithm

Unlike previousgroups, this type of algoritm focuses on adding security parameters to enhance smart video streaming. The Secure scalable streaming (SSS Framework) is considered as the first security scheme proposed by Wee and Apostolopoulos [25]. 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 [14].

Another approach is called the ARMS system proposed by Venkatramani, et.al [26]. 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 [4] [14]. Chiariglione, et.al [27] 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.

3.   RESEARCH METHOD

In order to answer the question of how to select the best among existing algorithms of video streaming and then apply it in a private cloud computing environment, many perspectives, and criteria should be involved and considered appropriately. Such case falls into multi criteria decision making (MCDM) problem. This study follows the approach usedin [3] that combines the Analytic Hierarchy Process [28] and ISO 9126 Software Engineering [29] to establish decision framework, which will be used to answer research question in this study.

AHP's simplicity and robustness makes it widely used to solve decision analysis problems in various fields [30]. Also, it offers flexiblity to combine tangible and intangible factors into a quantitative decision analysis structured within three basic layers namely, goal, criteria and alternative [31]. The first layer is called goal to be solved which is to select the best video streaming algorithm to be applied in private cloud computing. Then, ISO 9126 is international software evaluation standard that consists of six aspects of software engineering namely functionality, reliability, usability, efficiency, maintainable and portability [29]. It is widely accepted that the standard is applicable to review all aspects of software quality from preparation and development until evaluation stages [32]. The standard is applied on the second layer of the decision hierarchy as criteria.

Finally, on the third layer of AHP hierarchy is called the alternative. The alternative in this case are the four types of intelligent video streaming algorithms as mentioned previously in section 2. There are four altarnatives set in this study, namely Video Adaptation algorithm, Scalable Streaming algorithm, Video Summarization algorithm, and Secure Media Streaming algorithm. Tthe complete hierarchy of decision framework consists of three layers is shown in the following Figure 1.
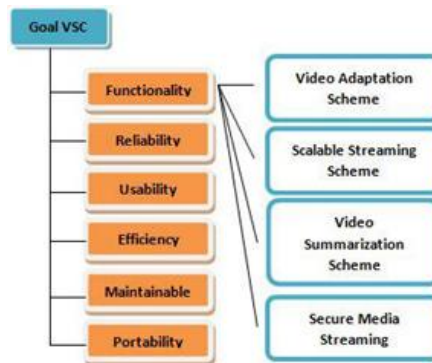
Figure 1. The decision analysis framework

According to Saaty [28], AHP analysis can be completed by taking the following five simple stepsas folows, Step 1: Decomposing decision framework in the form of a hierarchy consists of goal, criteria, and alternatives. Figure 1 depicts the framework hierarchy according to AHP method which consists of three layers. First layer is the goal of Selecting VSC (Video Streaming Cloud), the second layer is criteria of selection based on ISO 9126, and finally the last layer represents alternatives of four types of video streaming algorithms. Step 2: Collecting input from experts through survey based on the decision analysis hierarchy in the pairwise comparison of alternatives on a qualitative scale of from 1 to 9 and organizing them into a square matrix. Step 3: Calculating principal eigenvalue and the corresponding normalized right eigenvector of the comparison matrix. Step 4: Evaluating the consistency ratio (CR) of the matrix of expert's judgment. In case the value of CR is less than 0.1, judgment process must be revised. Step 5: Aggregating global weight ofcriteria to obtain the final ranking.

4.   RESULTS AND ANALYSIS

Expert Choice 2000 Academic Edition was used to perform the whole processes starting from constructing the decision analysis hierarchy, creating the AHP survey until the last step of determining final decision. The first step ofmodelling the decision structure in Expert Choice 2000 software is depicted in Figure 2. Based on the structure, list of AHP style's questionnaire might be automatically generated for both criteria and alternatives levels.
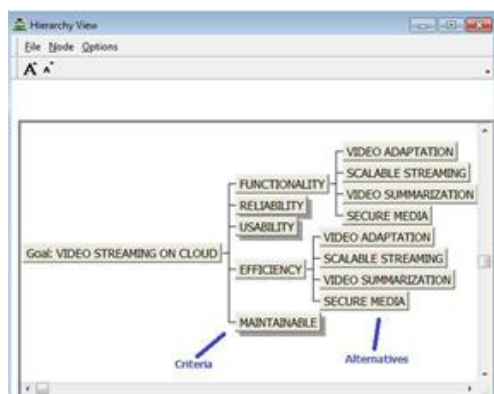

Figure 2. Modeling the decision structure

Figure 3. AHP questionnaire

The questionnaire uses 1-9 scale of Saaty which represents various values as follows. Equally Important or EI is represented as 1, Moderately Important or MI is represented as 3, Strongly Important or SI is represented as 5, Very Strongly Important or VSI is represented as 7 and finally Absolutely Important or AI is represented as 9 [28]. Furthermore, the decision maker should make his/her judgment in comparing

criteria from goal perspective in Figure 4 as well comparing alternative from criteria perspective in Figure 5. All judgment results are then collected in the software for further analysis steps. During the pairwise comparison process, some circumtances possibly resulting inconsistency of judgment by the decision maker. In this case, judgment should be repeated if the result considered inconsistent due to fails to satisfy AHP standard. This feature is called AHP consistency ratio, by which all pairwise comparisons are calculated and measured to ensure whole judgments are correctly done. According to AHP, maximum consistency ratio is 0.1. Therefore, if the calculated value is more than 0.1 then the decision process must be repeated until the acceptable value is achieved.
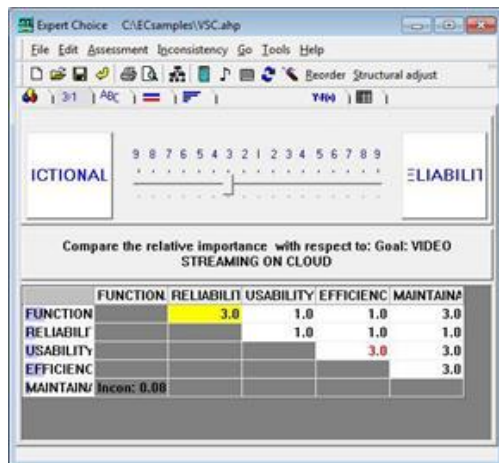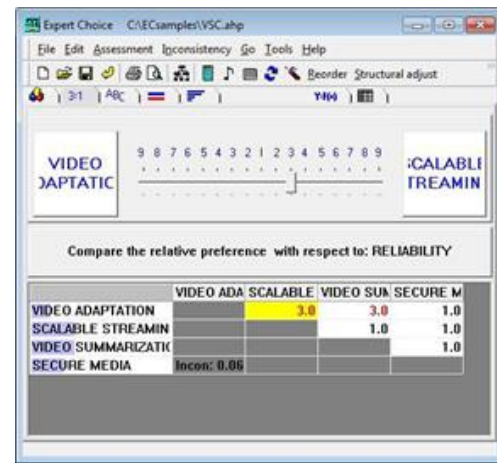

Figure 4. Pairwise comparison of criteria

Figure 5. Pairwise comparison of alternative

As can be seen in Figure 4 and Figure 5, the consistency ratio of the decision processesare 0.00 and 0.06 respectively which are both acceptable.Since all judgments are consistent, the next process might be proceed ofcalculating the final weight by aggregating all pairwise comparisons.The results are presented in Table 1.

Table 1. Final result of the decision analysis

No	Video Streaming Algorithm	Weight
1	Scalable Streaming	0.273
2	Video Summarization	0.267
3	Secure Media Streaming	0.245
4	Video Adaptation	0.215
	Overall consistency ratio : 0.09	

In comparison to other algorithms, Scalable Streaming algorithm is considered as the best choice for delivering video contents over cloud infrastructure which accounted for 0.273. The second one is Video Summarization algorithm by 0.267 followed by Secure Media algorithm and Video Adaptation algorithm by 0.245 and 0.215 respectively. Overall inconsistencyratio is 0.09 which means that whole judgments are consistent and thus the result is acceptable.

The findings obtained from this research are in line with some of the latest research in the field of cloud computing and video streaming. The concept and applications of video streaming algorithms on public cloud computing for commercial needs is not newsuch as Netflix [33], but its application to private cloud computing for non-commercial needs such as education and government as adopted in this study is a novel approach. Therefore decision makers in this case require a comprehensive mechanism in viewing the issue in this case the selection of the best streaming video algorithm for application to private cloud computing [4].

Li et al [34] states that the integration of streaming video services on the cloud infrastructure is inevitable for two reasons, firstly increasing user demand that is uplink bandwidth at end users, and socondly the increasingly abundant availability of bandwidth in the Internet that is the downlink bandwidthat the servers in the cloud datacenters. Hence, the combination of video streaming on cloud computing infrastructure is the need for current video on demand services [35].

Since cloud computing technologies are basically well prepared to offer scalable resources to content or service providers [36], then cloud data centers can easily supportive to large-scale real-time video services as argued by Zhuang et.al [37]. As a result, scalable streaming algorithm will fit properly within private cloud infrastructure to solve the problem in this case.

5.   CONCLUSION

The problem on how to select the best video streaming algorithm for private cloud computing infrastructure is addressed in this paper. Analytic Hierarchy Process is succesfully combined with ISO 9126, an international standard for software engineering, to develop a new decision analysis hierarchy, followed by an example to assist the decision making processes. Among four types of intelligent algorithms, Scalable Streaming algorithm is found as the best choice since it obtains the highest weight of 0.273 with overall consistency ratio of 0.09. Based on the findings it can be concluded that Scalable Streaming algorithm is the best option to be applied in the case of improving the quality of video streaming contents delivered over private cloud computing infrastructure. In the future, the study might be extended in two ways, first by performing simulation of AHP sensitivity analysis within various what-if scenarios, and secondly evaluation of algorithm performance against various quantities of cloud users.

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