Object based Scalability Support for Adaptive MPEG-4 contents

Kyung-Ae Cha[1], Hyun-Jin Kim[2]
[1,2] School of Computer and Communication Engineering, Daegu University, Gyeonsan, Korea

Abstract – In this paper, an adaptive algorithm is proposed in streaming MPEG-4 contents with fluctuating resource amount such as throughput of network conditions. MPEG-4 is the international standard for audio-visual presentation which is composed of object based media streams. The proposed technique provides the media stream corresponding an object with multiple media streams with different qualities and bit rate in order to support object based scalability to the MPEG-4 content. In addition, making the object streams adaptable, a feasible stream set selected from the multiple streams for transmission with optimal quality in the form of the current status.

Keywords: MPEG-4, adaptive streaming.

1 Introduction

One of the problems encountered when a multimedia service is performed in a heterogeneous environment is the variation in the receiver's capability or the fluctuation of network throughput [1, 2]. Therefore, providing an adaptive transmission scheme in the server is essential in rendering the appropriate contents to the specific receiver. This paper sought to transmit MPEG-4 contents making highly efficient use of the available resources.

An MPEG-4 scene is composed of individual audio-visual objects, with the arrangement of objects specified by the scene description. The individual media corresponding to objects are carried in separate Elementary Streams (ES) [3]. Thus, an MPEG-4 content can be represented as a set of objects. MPEG-4 provides an object based scene representation framework in which multiple objects are represented and rendered in a single scene. Each object in an MPEG-4 scene may consist of multiple elementary streams represented at different layers. The elementary streams for the same object may differ in encoded bit-rates, resolutions, etc. So it is required that an optimal set of MPEG-4 objects need to be selected to meet given resource constraints. The corresponding MPEG-4 scene is therefore necessary to be adapted according to the changes in configuration of the MPEG-4 objects in the scene.

2 Objects composing MPEG-4 content

MPEG-4 enables the author of a multimedia scene to accurately render his composition by parsing a scene description, which effectively defines the structure of the different types of media objects in space and time.

Let M be an MPEG-4 content to be transmitted. Thus, M is represented as { Oi | Oi is a media object, i = 1, 2, ...n}. In addition, the objects are assigned values with the following features to be provided MPEG-4's own features as well as proposed adaptive scheme.

Temporal interval: Objects present their temporal intervals as a result of the scene description. The temporal duration's start and end times of an object are represented as Oi.st and Oi.et, respectively.

Stream layer: Elementary streams such as image, audio, and video streams are encoded, layered by their own characteristics. The quality of the layered stream is measured by the signal-to-noise ratio (SNR). According to the SNR, the perceptual quality assigned to each stream layer of an object is in the unit interval [0, 1]. Oij is denoted as the jth stream of object Oi, with Pij and Sij the perceptual quality and the encoded bit rate of the stream, respectively.

Object priority: Object priority refers to the value of the priority among objects as assigned by the content author. It is denoted as Oi.p for object Oi..

3 Adaptive Streaming

If the set of objects to be transmitted at time t is denoted as Mt, then Mt is represented as Mt = { Oi | Oi.st < t < Oi.et, Oi ∈ M, i = 1, 2, ...n}

The total bit rate of Mt is estimated as :

$$BR(M_t) = \sum_{O_i \in M_t} BR_t(O_i),\ i = 1,2,\ldots,n$$

where BR(Oi) is the original encoded bit rate of object Oi $\in$ Mt.

The objective of adaptation is to find a stream layer of objects to maximize the overall quality of transmitted streams. To divide the problem into several sub-problems, the following feasible sets are defined:

FSMt = {Oij | Xij = 1, i = 1, 2, ...N, j = 1, 2, ...ni} satisfies the following constraints.

$$\text{Maximize} \quad \sum_{i=1}^{N}\sum_{j=1}^{n_i} P_{ij} X_{ij}$$

$$\text{Subject to} \quad \sum_{i=1}^{N}\sum_{j=1}^{n_i} S_{ij} X_{ij} \le C \text{ and } \sum_{j=1}^{n_i} X_{ij} = 1$$

$$X_{ij} \in \{0, 1\} \text{ for } i = 1,2,\ldots,N \text{ and } j = 1,2,\ldots,n_i$$

FSMPt ={Oij | Xij = 1, i = 1, 2, ...N, j = 1, 2, ...ni} satisfies the following constraints.

$$\text{Maximize} \quad \sum_{i=1}^{N}\sum_{j=1}^{n_i} P_{ij} X_{ij} O_i.p$$

$$\text{Subject to} \quad \sum_{i=1}^{N}\sum_{j=1}^{n_i} S_{ij} X_{ij} \le \text{C and } \sum_{j=1}^{n_i} X_{ij} = 1$$

$$X_{ij} \in \{0, 1\} \text{ for } i = 1,2,\ldots,N \text{ and } j = 1,2,\ldots,n_i$$

Here, N is the number of objects within Mt and ni the number of stream layers of object Oi. Moreover, the available resource size reported by the network or receiver is denoted as C.

The above sets guarantee that media streams corresponding to all objects will be transmitted, although the qualities of some media streams are degraded. The following sets are the results considered by the adaptive algorithm for dropping lower-priority objects when media streams are transmitting:

FSPZt = {Oi | Xi = 1, i = 1, 2, ...N} satisfies the following constraints.

$$\text{Maximize} \quad \sum_{i=1}^{N} O_i.p X_i$$

$$\text{Subject to} \quad \sum_{i=1}^{N} BR(O_i) X_i \le C$$

$$X_i \in \{0, 1\} \text{ for } i = 1,2,\ldots,N$$

FSMZt ={Oij | Xij = 1, i = 1, 2, ..., N, j = 1, 2, ...ni} satisfies same constraints of the FSMt with the third constraint as $\sum_{j=1}^{n_i} X_{ij} \le 1$.

The adaptive algorithm represented in Fig. 1 tries to find FSMt and FSMPt from Mt in turn. If it cannot find the feasible set, it finds the set from the high-priority object set [denoted as HP(Mt)]. According to the results of these trials, the algorithm finds FSPZt or FSMZt. Note that the available throughput at time t is denoted as Bavail(t). The optimal media stream set can be found using known schemes such as backtracking, branch and bound method, and approximation algorithms. In this research, the backtracking method was used to select a subset of stream objects to be included in the MPEG-4 scene and consequently provide optimized efficiency to the receiver.

```
Input : Mt, Bavail(t)
Output : FSt
Initialize : FSt = Ø
Method
Begin
 If BR(Mt) > Bavail(t)
   if Bavail(t)-BR(HP(Mt)) > 0
       Find FSMt from Mt-HP(Mt) with C = Bavail(t)-BR(HP(Mt))
       FSt = FSMt
       if FSt = Ø
          Find FSMPt from Mt with C = Bavail(t)
          if FSMPt = Ø
             Find FSPZt from Mt-HP(Mt) with
                                      C = Bavail(t)-BR(HP(Mt))
             if FSPZt = Ø
                Find FSMZt from Mt-HP(Mt) with
                                      C = Bavail(t)-BR(HP(Mt))
                FSPZt = FSMZt
             end if
             FSt = FSPZt U HP(Mt)
             exit
          end if
          else
             FSt = FSMPt
             exit
          end else
       end if
       else
          FSt = FSt U HP(Mt)
       end else
   end if
 else
   Find FSMPt from Mt with C = Bavail(t)
   if FSMPt = Ø
       Find FSMPt from HP(Mt) with C = Bavail(t)
       if FSMPt = Ø
          Find FSPZt from HP(Mt) with C = Bavail(t)
          if FSPZt = Ø
             Find FSMZt from HP(Mt) with C = Bavail(t)
             FSt = FSMPt
          end if
          else
             FSt = FSMPt
          end else
       end if
       else
       FSt = FSMPt
       end else
   end if
   else
       FSt = FSMPt
   end else
End
```

Fig. 1 Adaptive algorithm

4 Simulation results

The characteristics of the sample MPEG-4 stream and the simulated bandwidth fluctuate through time as shown in Fig. 2. Using the proposed algorithm, the adaptive stream does not exceed the available bandwidth despite the high degree of usage of the network resource.

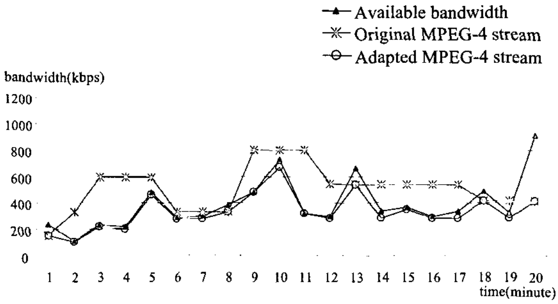

Fig. 2. Comparison of bit rate of original MPEG-4 stream and adaptive stream

The perceptual quality of streams that will be decoded at the receiver is denoted as *Average_RPQ* and estimated as:

$$Average\_RPQ_t = \sum_{i=1}^{n} O_i.priority \times RPQ_i / \sum_{i=1}^{n} O_i.priority$$

where RPQ_i pertains to the relative perceptual quality of the adaptive stream for object O_i and n the number of objects to be transmitted at time t.

Fig. 3 presents a comparison of *Average_RPQ* of the adaptive streams using the proposed algorithm and that of the adaptive streams by dropping media streams. The proposed algorithm was found to transmit more high-quality streams.

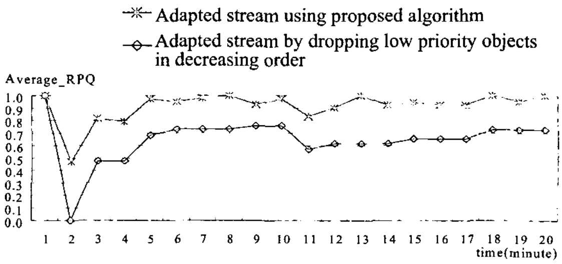

Fig. 3. Comparison of average relative perceptual quality

5 Conclusions

This paper presented an adaptive algorithm to provide a set of elementary stream adaptation mechanisms based on the transmission throughput. The selective scheme that considers multiple streams helps in enabling the MPEG-4 contents to adapt to the various end systems and to the fluctuation of network conditions.

References

1. A. Mahajan, P. Mundur and A. Joshi : 'Adaptive multimedia system architecture for improving QoS in wireless networks', LNCS2532, Springer, December, 2002, pp. 713-719.
2. D. Turner and K.W. Ross : 'Optimal streaming of a synchronized multimedia presentation with layered Objects', IEEE International Conference on Multimedia and Expo, July 2000, pp. 263-266.
3. C. Herpel and A. Eleftheriadis : 'MPEG-4 Systems: elementary stream management', Signal Processing: Image Communication, 15 (4-5), January 2000, pp. 299-320.
4. P. Batra, "Modeling and efficient optimization for object-based scalability and some related problems," IEEE Trans. Image Processing, vol. 9, no. 10, October 2000, pp. 1677-1692..