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A P2P unequal playback length segmentation and scheduling algorithm based on scalable video coding[1]

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Abstract. P2P streaming media system based on SVC often use equal playback length segmentation algorithm to segment the video data, but the size of the data in different segmentation varies widely using this segmentation algorithm, which can lead to the instability of data transmission. In this case, a new unequal playback segmentation in P2P streaming media system based on SVC has been presented, and a new scheduling algorithm has been presented on the basis of the new unequal playback segmentation. Finally, the experimental results show that the new unequal playback segmentation and scheduling algorithm based on SVC can reduce the complexity of the enhancement layers scheduling in P2P system and enhance the stability of data transmission in P2P network system, and it is a kind of effective P2P streaming media segmentation and scheduling algorithm.

Key words. SVC, P2P, segmentation algorithm, segmentation scheduling algorithm.

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1. Introduction

With the development of information technoloogy, P2P streaming media technology will get more development. But how to transfer and share video data in heterogeneous environments becomes the main problem. In order to solve this problem, a variety of adaptive techniques are proposed, including trans-coding, simulcast, multiple description coding and SVC (Scalable Video Coding). SVC is the best solution for this problem because of its efficient coding efficiency, convenient self-adaptability and high sharing [1–3].

At present, in the most P2P video streaming system based on SVC, the video data is layered, then the video data for each layer is segmented according to an equal playback length segmentation algorithm, and the playback length of each segmentation of all the layers of video data is the same. And the equal playback length segmentation algorithm can meet the data synchronization requirements between layers in the progress of decoding and playing the video data.

However, using the equal playback length segmentation algorithm, the size of the segmentation data in different layers is very different, and the size of segmentation data in the same layer is also different, and this can lead to the instability of data transmission in P2P network system [4–7].

This paper discusses how to segment the SVC data when it is applied in P2P streaming media system, and a P2P streaming media unequal playback segmentation and scheduling algorithm based on SVC is proposed in this paper.

2. The P2P segmentation algorithm based on SVC

2.1. The first segmentation

First, for the encoded SVC video data, each NAL (Network extraction layer) unit is sequentially read, and the identification of the spatial layer d, the identification of the time layer t, the identification of the quality layer q and the length of NAL unit in the header of NAL are extracted. The SVC video data is divided into several layers according to the value of d, t, q, and each layer is composed of the NAL units, the d, t, q of which is the same. The data of one layer are stored in accordance with the original order of SVC video data. The data size of each layer $s\,(d,t,q)$ is calculated by Eq. (1):

$$s\,(d,t,q) = \sum_{i=1}^{n} z\,(i), \tag{1}$$

In the equation, $s\,(d,t,q)$ is the data size of the (d,t,q) layer, and $d \in \{0,1,...,a-1\}$, $t \in \{0,1,...,b-1\}$, $q \in \{0,1,...,c-1\}$, a, b, c respectively represents the number of spatial layers of the SVC video, the number of time layers of the SVC video and the number of quality layers of the SVC video; $z\,(i)$ is the size of the i th NAL unit in the Layer (d,t,q), and n is the number of NAL units in the Layer (d,t,q).

Then, calculate the reasonable number of GOPs of the segmentation in the base layer. After the SVC video data is layered, the reasonable number of GOPs $m\,(0,0,0)$

included in each segmentation of the base Layer $(0,0,0)$ is calculated when using equal playback length segmentation method, and the equation is as follows:

$$m(0,0,0) = ROUND\left(\frac{Z \times M}{2 \times s(0,0,0)}\right) \times 2, \tag{2}$$

In Eq. (2), $m(0,0,0)$ represents the reasonable number of GOPs contained in each segmentation in the base layer $(0,0,0)$, $s(0,0,0)$ represents the data size of the base layer $(0,0,0)$, M represents the number of GOPs contained in layer $(0,0,0)$ of the SVC video after layered, Z represents the data size of the segmentation in the P2P streaming media system according to the conventional non-layer equal data size segmentation method, d is the rounding function.

Next, calculate the reasonable number of GOPs of the segmentation in the remaining enhancement layers. In the paper, the exponential function of 2 is used to segment the enhancement layers of SVC video according to the equal playback length segmentation method, so as to ensure the overall synchronization of all the layers in time. Besides, the complexity of the enhancement layers scheduling method in the P2P system is reduced by limiting the playback length of the enhancement layers whose data size is larger than the data size of the base layer, and the value of the playback length of the segmentation in these enhancement layers is [1/2, 1] times the playback length of the base layer. The equation is as follows:

$$m(d,t,q) = \begin{cases} m(0,0,0) \times 2^{\left\lceil \log_2 \frac{s(0,0,0)}{s(d,t,q)} - \log_2 1.5 \right\rceil}, & s(0,0,0) > 0.75 s(d,t,q) \\ m(0,0,0)/2, & s(0,0,0) \leq 0.75 s(d,t,q) \end{cases}, \tag{3}$$

In Eq. (3), $m(d,t,q)$ is the reasonable number of GOPs contained in the segmentation of the enhancement layer (d,t,q) in the SVC video data, $m(0,0,0)$ is the reasonable number of GOPs contained in the segmentation of the base layer $(0,0,0)$, $s(0,0,0)$ is the data size of the base layer $(0,0,0)$, $s(d,t,q)$ is the data size of the enhancement layer (d,t,q), the values of d, t, q can not be 0 at the same time, and the symbol $\lceil\rceil$ is rounded up.

Finally, Segment the Layer (d,t,q) according to $m(d,t,q)$ the reasonable number of GOPs contained in the segmentation of the layer (d,t,q), and Layer (d,t,q) is divided into $\lceil M/m(d,t,q)\rceil$ segmentation, M is the number of GOPs contained in layer (d,t,q) after layered, $d \in \{0,1,...,a-1\}$, $t \in \{0,1,...,b-1\}$, $q \in \{0,1,...,c-1\}$.

Therefore, the each preceding $\lfloor M/m(d,t,q)\rfloor$ segmentation of the Layer (d,t,q) contains $m(d,t,q)$ GOPs, and if the number of GOPs contained in the last segmentation of the layer (d,t,q) is not equal to the number of GOPs contained in the preceding $\lfloor M/m(d,t,q)\rfloor$, the number of GOPs contained in the last segmentation of the layer (d,t,q) is $M - m(d,t,q) \times \lfloor M/m(d,t,q)\rfloor$, and the symbol $\lfloor\rfloor$ is rounded down.

2.2. The second segmentation

In this paper, the segmentation with the larger data size are segmented for the second time in order to enhance the stability of data transmission in P2P network system.

If the data size of the segmentation is greater than or equal to 2 Z, the segmentation is segmented for the second time using the algorithm based on the data size shown in Eq. (4) and Eq. (5):

$$p_{i,1} = \left\{ GOP_j \left| GOP_j \in P_i \wedge \left(\sum_{k=1}^{j} s\left(GOP_k\right) \leq \frac{s\left(P_i\right)}{2} \vee \right. \right. \right. \tag{4}$$
$$\left. \left. \left(\sum_{k=1}^{j-1} s\left(GOP_K\right) \frac{s\left(P_i\right)}{2} \wedge \sum_{k=1}^{j} s\left(GOP_k\right) \frac{s\left(P_i\right)}{2} \right) \right) \wedge s\left(P_i\right) \geq 2Z \right\},$$

$$P_{i,2} = P_i - P_{i,1}. \tag{5}$$

In the equation, $P_{i,1}$ stands for the first child segmentation of the segmentation P_i after the segmentation P_i is segmented using the secondary segmentation method, and $P_{i,2}$ stands for the second child segmentation of the segmentation P_i after the segmentation P_i is segmented using the secondary segmentation method, and GOP_j stands for the j^{th} GOP of the segmentation P_i; $s\left(P_i\right)$ stands for the data size of the segmentation P_i; $s\left(GOP_k\right)$ stands for the data size of the k^{th} GOP of the segmentation P_i; Z represents the data size of the segmentation in the P2P streaming media system according to the conventional non-layer equal data size segmentation method.

$P_{i,1}$ is composed of the preceding j GOPS of the segmentation P_i, and these preceding j GOPS meet the following conditions:

The total data size of these preceding j GOPS is greater than or equal to $s\left(P_i\right)/2$;

But the total data size of these preceding $j-1$ GOPS is less than $s\left(P_i\right)/2$;

The second child segmentation $P_{i,2}$ is composed of the remaining GOPS of the segmentation P_i which aren't contained in the first child segmentation $P_{i,1}$.

3. The scheduling algorithm

On the basis of the unequal playback length segmentation algorithm of P2P streaming media, a scheduling algorithm is proposed, and specific steps are as follows:

1). The client selects the SVC video layers that needs to be played, then obtains the P2P index information of the selected SVC video layers;

2). When playing in sequence, the client request the segmentation data layer by layer in accordance with the order playing order, the specific steps are as follows:

2-1). Because the number of GOPs corresponds to the playback length, the longer the number of GOPs, the longer the playback length, the smaller the number of GOPs, the shorter the playback length. Therefore, according to the reasonable number of GOPs contained in the segmentation of the SVC video layers selected by the client, the maximum playback length $m_{\max}(d,t,q)$ of the segmentation using the equal playback length segmentation algorithm is calculated.

2-2). With T for the time period, the data of the segmentation of the SVC video layers selected by the client are requested synchronously layer by layer, and in the nth synchronization time period, the number of segmentation of each layer is computed by Eq. (6) and Eq. (7).

$$P_{count}(d,t,q) = \frac{T}{m(d,t,q)} + \sum_{i=\frac{(n-1)T}{m(d,t,q)}+1}^{\frac{nT}{m(d,t,q)}} A_{d,t,q}(i), \tag{6}$$

$$T = N \times m_{\max}(d,t,q). \tag{7}$$

In the formula, $P_{count}(d,t,q)$ denotes the number of segmentation of Layer (d,t,q) are requested by the client in the nth synchronization time period. Both n and N are positive integers, T is the synchronization time period, and the vale of T is an integer multiple of the maximum playback length $m_{\max}(d,t,q)$, and $m_{\max}(d,t,q)$ is the maximum playback length of the segmentation of the SVC video layers selected by the client using the equal playback length segmentation algorithm. $A_{d,t,q}(i)$ denotes whether the segmentation of the Layer (d,t,q) is segmented twice, and the i denotes the index position in the storage space A.

2-3). After the segmentation of the SVC video layers requested by the client in a time period T are received, the decoder decodes and plays the received segmentation data, t the same time, the segmentation of the SVC video layers requested by the client in another T time period begin to be received.

3). When playing the video at a certain time point t' by the way of dragging, the client locates and requests the segmentation which need to be downloaded according to the time information of the segmentation in the P2P index.

3-1). It is first judged that the video data at a certain time point t' belongs to which GOP.

3-2). Then calculate that the GOP is in which segmentation of each layer of the video, which is calculated by Eq. (8)and Eq. (9).

$$np = \left\lceil \frac{ng}{m(d,t,q)} \right\rceil + \sum_{i=1}^{\left\lfloor \frac{ng}{m(d,t,q)} \right\rfloor} Ad,t,q(i) + n', \tag{8}$$

$$n' = \begin{cases} 0, ng\%m(d,t,q) = 0 \vee Ad,t,q\left(\left\lceil \frac{ng}{m(d,t,q)} \right\rceil\right) \\ \qquad = 0 \vee ng\%m(d,t,q) \leq Bd,t,q\left(\left(\sum_{i=1}^{\left\lfloor \frac{ng}{m(d,t,q)} \right\rfloor} Ad,t,q(i)\right) + 1\right) \\ 1, ng\%m(d,t,q) \neq 0 \wedge Ad,t,q\left(\left\lceil \frac{ng}{m(d,t,q)} \right\rceil\right) \\ \qquad \neq 0 \wedge ng\%m(d,t,q) > Bd,t,q\left(\left(\sum_{i=1}^{\left\lfloor \frac{ng}{m(d,t,q)} \right\rfloor} Ad,t,q(i)\right) + 1\right) \end{cases}. \tag{9}$$

In the formula, n_p denotes the GOP is in which segmentation of the layer (d,t,q) of the SVC video; n_g denotes the video data at a certain time point t' belongs to which GOP; $m(d,t,q)$ is the reasonable number of GOPs contained in the segmentation of the layer (d,t,q) after segmented using the equal playback length, $A_{d,t,q}(i)$ denotes whether the segmentation of the Layer (d,t,q) is segmented twice, and the i denotes the position in the storage space A.

$B_{d,t,q}(i)$ denotes the number of GOPS of the segmentation after the segmentation is segmented twice in the Layer (d,t,q) and the i denotes the position in the storage space B.

3-3). Download these segmentation from the layers of the SVC video, and get the video data needed to play.

4. Results and discussion

The purpose of the simulation experiment is to compare the transmission performance of the data segmentation generated by the two segmentation algorithms in the network. The main work of the simulation experiment is to simulate the transmission of data packets, and these packets have the segmentation characteristics generated by the two segmentation algorithms. In the simulation experiment, the performance of the two algorithms are compared by analyzing mean and standard deviation of the data packets transmission delay.

Experiments using OverSim simulation software for packet transmission simulation. For the two algorithms, the two kinds of segmentation of the same video are transmitted respectively. The number of segmentation using the equal playback length segmentation is 391, and the number of segmentation using the unequal playback length segmentation algorithm proposed in the paper is 396. In the experiment, the transmission delay of all the packets in the transmission process is collected, then analyze statistically them. In the experiment, in order to more realistic simulation of the real network, so in the network to join the network background flow. There are two kinds of network background flow: long service flow which is a long duration of flow transmission; short service flow which is a short duration of flow transmission.

These two kinds of service flow are generated in a random time of the simulation process, and the number of occurrences is also random. Figure 1 is the network topology used in the simulation experiment. In the figure, the data sending node generate data packets and send them to the data receiving node. And in order to simulate the background flow in the network, the short service flow sending node and the long service flow sending node respectively generate the service flow and send them to the service flow receiving node, to transmit the background flow in the network. The link bandwidth between the two routers can be regarded as the access bandwidth of the data receiving node.

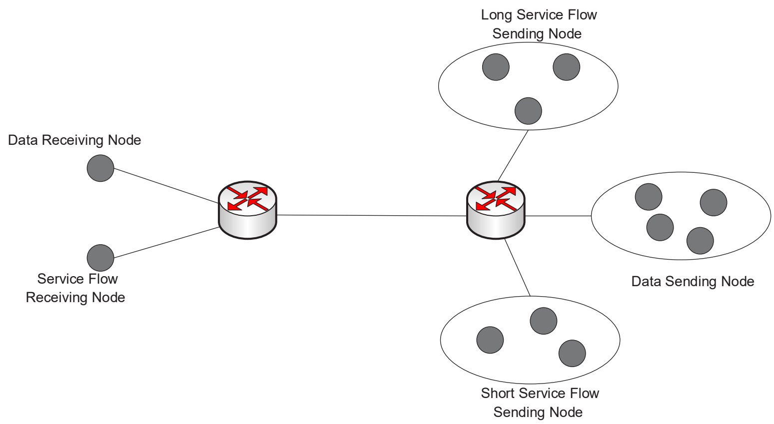

Fig. 1. The network topology of the simulation experiment

As can be seen from the data in Table 1, the difference between the mean of the data packets generated by the two segmentation algorithms is smaller. However, the standard deviation of the transmission delay of the data packets generated by the equal playback length segmentation is large, which leads to the instability of the transmission, and the factors such as the packet loss rate of the transmission process, which affects the efficiency of data transmission. The standard deviation of the transmission delay is close to zero when the segmentation generated by the unequal time segmentation algorithm proposed in the paper is transmitted, which means that the whole transmission process is very stable and helps the client to design the scheduling algorithm of the segmentation.

Table 1. Data statistics of transmission delay for the two segmentation algorithms.

	The unequal playback length segmentation		The equal playback length segmentation	
The bandwidth of the access network	Mean (sec)	Standard deviation (sec)	Mean (sec)	Standard deviation (sec)
500KB	1.441877	0.339258	1.764087	1.688674
1MB	0.736482	0.163286	0.887078	0.749156

After the comparison of the transmission performance in the simulation experiment, we can see that the unequal time segmentation algorithm proposed in the paper is better than the equal playback length segmentation algorithm.

5. Conclusion

In this paper, P2P streaming media segmentation algorithm based on SVC is researched. On the basis of the research, this paper proposed a new segmentation and scheduling algorithm, in the new algorithm, the video is segmented twice, first segment the video data of each layer according to the number of GOPs which should be contained in the segmentation of each layer, and after first segmented, the segmentation of the same layer have the equal playback length, then segment the segmentation with the larger data size using the second segmentation algorithm. Finally, the experimental results show that using unequal playback length segmentation algorithm proposed in the paper can enhance the stability of data transmission.

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