Temporal Distance based Particle Domain Selection Method for Large Scale Streaming System

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Abstract. Network based video proxy server can store the videos in order to minimize initial latency and network traffic significantly. However, due to the limited storage space in video proxy server, an appropriate video selection method is needed to store the videos which are frequently requested by clients. Thus, we propose a temporal distance based particle domain selection method using concurrent request pattern in large scale streaming system. We exploit the short-term temporal locality of two consecutive requests on an identical video. If the video is requested by user, it is temporarily stored during the predefined interval and then, delivered to the user. Due to the limited storage area in video proxy server, it is often required to replace the old video which is not serviced for long time with the newly requested one. This replacement causes the service delay and increase of network traffic. To circumvent this problem, we also propose an efficient deletion scheme in a video proxy server.

Keywords: multimedia streaming, video proxy server, delivery technique, QoS management, video-on-demand service.

1 Introduction

A video proxy server is essentially a middle computer system that sits between the client and the content server which is located at the remote location [1-3]. By storing video data, a video proxy server close to the clients can be used to assist video delivery and alleviate the load of content servers. This video proxy server can partially satisfy the need for rapid multimedia data delivery by providing multiple clients with a shared storing location. The requested videos are always delivered from the content server through the video proxy server to clients, thus the video proxy server is able to intercept and store these videos to decrease the amount of video data that has to be delivered by the content server. In this context, if a requested video exists in a storage area in video proxy server, clients get a stored video, which delivery time is typically reduced. The storing and deletion technique of video proxy server is one of the key solutions to improve the performance of multimedia service systems on the large scale network environment. However, since the storage capacity of video proxy server does not have an infinite-capacity for keeping all the continuous video data, the challenge for the video proxy server is to determine which videos

should be stored or removed from the storage area of video proxy server. Due to the large sizes of streaming media objects, these algorithms are not providing optimal performance large scale network environment. In video proxy server, most media objects should be stored partially to save the storage space efficiently. This leads us to a segment-based approach to proxy storing of large media objects. The motivation of media segmentation is that we can quickly discard a big chunk of a stored media object that was once hot but has turned cold. In this way the storage manager of video proxy server can quickly adjust to the changing reference patterns of partially stored object [4-5]. However, to the best of our knowledge, none has dramatically utilized the effectiveness of media segmentation approach for large media objects and considered the time-variable request pattern by clients. Thus, we propose the temporal distance based particle domain selection method as well as time-based approach to minimize the initial latency, central server load, and network traffic significantly.

2 Temporal Distance based Particle Domain Selection

In this section, we present the temporal distance based partial domain selection method for large scale streaming system. We exploit the short-term temporal locality of two consecutive requests on an identical video.

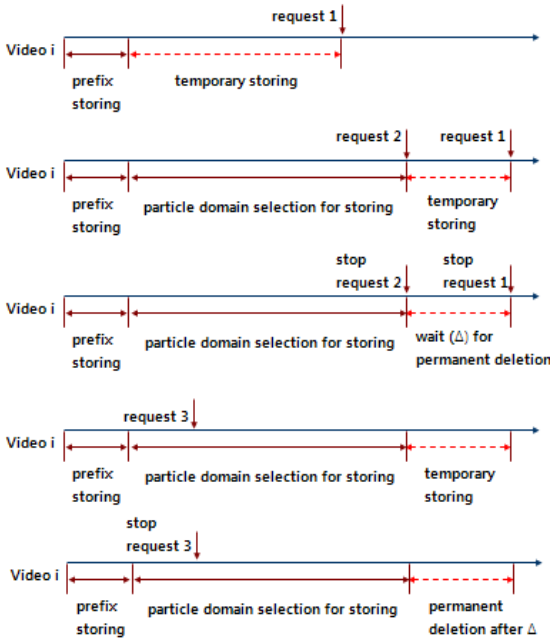

Fig. 1. The scenario of temporal distance based particle domain selection method.

For this purpose, videos are divided into segments of equal length and the video proxy server loads the requested video segment which is delivered from the content server in temporary storage area and forwards it to users directly.

The requested video segment is not residing in the video proxy server in first loaded in temporary storage area. But, if the same video segment is requested once again by a different user in case when the previous request is consuming the same video, we utilize the time distance between the earlier request and the latest request. Within this time distance, video proxy server can preserve the segment which is delivered by the latest request in temporary storage area. In addition, if the new request starts to utilize the video in temporary storage area, video proxy server can store the segments which are utilized by the new request in order to exploit the finite-capacity storage area efficiently. We expect that this video will be requested a lot of times within a short time. Fig. 1 depicts the detail scenario of our temporal distance based particle domain selection method. In Fig.1, prefix size and expectation time (Δ) of video i is determined by average initial latency within a predefined delay time, $\mu_i(k)$, and calculated by equation (1) respectively. In this paper, optimal value of predefined interval is derived by simulations.

$$\mu_i(k) = \frac{1}{n}\sum_{i=1}^{n}\alpha_i(k) \quad \textbf{(1)}$$

where, n denotes total number of segment k and $\alpha_i(k)$ represent the time difference between recently request time and its previous request time.

Since the storage space of video proxy server does not have infinite-capacity storage for keeping all the continuous video data, the video proxy server should have an appropriate deletion algorithm to make storage space for newly stored data in case when there is not free space enough to hold the new one. The challenge for the deletion algorithm is to determine which video segment should be stored or removed from the storage area of video proxy server. The crucial aspect of deletion algorithm lies in selecting victim. This deletion causes the service delay and increase of network traffic. To circumvent this problem, we propose an efficient deletion scheme in a video proxy server. In this paper, a video is divided to two groups, that is, preservation segment group and deletion segment group using equation (2).

$$\lambda_i(k) = \{Cnt_i(k) - Cnt_i(k+1)\}\ k=1, 2, ..., n. \quad \textbf{(2)}$$

where, $\lambda_i(k)$ denotes the difference value of request number of segment k and $Cnt_i(k)$ and $Cnt_i(k+1)$ represent request number of segment k and k+1, respectively.

We select the key segment which remarks the maximum request difference value and remove the last segment when the storage capacity is running out of space. Fig. 2 depicts the preservation segment group and deletion segment group.

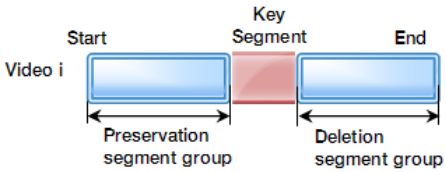

Fig. 2. Preservation and deletion segment group.

In addition, if a segment which is located in preservation segment group of video i is not requested within a predefined delay time, $\mu_i(k)$, this segment is moved to deletion segment group automatically.

3 Performance Evaluations

In general, hit rate has been used as the performance measurement of the storage schemes for traditional data such as text and image. But it is not proper for continuous media data. Thus, we use the hit rate of block defined as a segment, which can reflect the proxy server management method. In addition, we also use the number of block deletion in order to verify the efficiency of storage management method more correctly. We compare our method with the well-known algorithms such as PLFU(Partial Least Frequently Used) [6], Distance-based [7] and Reallocation Affinity [8] method through simulations. In order to verify the effectiveness of the proposed method, we conduct simulation under fixed-length segmentation. We consider a set of approximately 654Mbyte long videos and assume that the request rate is 1,200 per minute. The detail simulation parameters are shown in Table 1.

Table 1. Simulation Parameters.

Parameter	Value
Simulation time	72 hours
Number of video	1,200
Video size	654.7 MB
Bit rate	1,024 Kbps
Block play time	5 sec
Request time	1,200 per minute
Storage size	50, 100, 150, 200, 250, 300, 350 GB

In our simulation, to verify the effectiveness of our method, we conduct simulations under random access pattern when the video proxy storage sizes of 50, 100, 150, 200, 250, 300, and 350GB are used respectively.

Fig. 3 shows that the hit rate of our method compared with that of other well-known algorithms. The simulation results show that the proposed algorithm performs better than other algorithm such as PLFU, Distance-based and Reallocation Affinity method in terms of block hit rate.

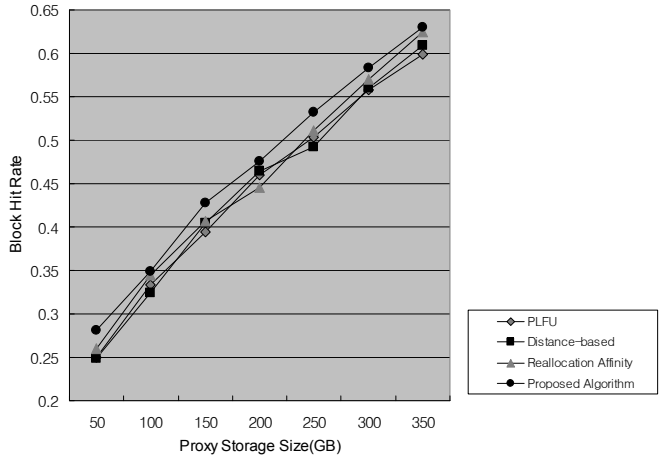

Fig. 3. Comparison of block hit rate under various video proxy server storage sizes.

Fig. 4 shows the efficiency of our temporal distance based partial domain selection method, where the number of deletion of our method is significantly fewer than that of other algorithms. This improvement may be due to the fact that the segmented video which represents a low request ratio can be deleted quickly in storage area. Therefore, we prove that the deletion overhead of our method is not significant compared to other algorithms.

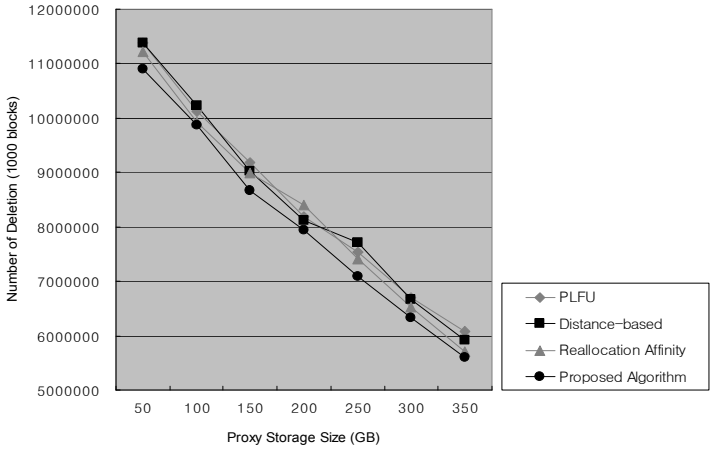

Fig. 4. Comparison of number of block deletion under various video proxy server storage sizes.

4 Conclusions

The storing and deletion technique of video proxy server is one of the key solutions to improve the performance of multimedia applications on large scale network environment. By storing frequently accessed video data at a storage area, client perceived latency, central server load, and network traffic can be reduced significantly. However, since existing storing techniques are for traditional data such as text and image, they are not suitable to continuous media data. In this paper, we present a temporal distance based particle domain selection method using concurrent request pattern in large scale streaming system. Thus, we can save storage space without degrading performance in video proxy server. Through simulation, we evaluate the performance of our video proxy server management method and compared with other well-known algorithms such as PLFU, Distance-based and Reallocation Affinity method. We demonstrate that the introduction of the concept of partial storing and deletion leads to better performance

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