A VIDEO DELIVERY METHOD USING AVAILABLE BANDWIDTH OF LINKS WITH BUFFERS AND DISKS

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Abstract: Scheduling policies and methods are required to deliver videos through network structure since the videos are key contents, and they are continuous media, in order to design the networked multimedia systems. These systems allocate resources before video clips leave their servers for guaranteeing continuous play of the videos. The policies for achieving video delivery play an important role in sense of effective delivery. The method for utilizing the links is a momentous problem, since their capabilities are restricted, and extensions of their capabilities are a difficult issue. The policy shown in this paper is that available network bandwidth is used for delivering one video clip at once. The bandwidth of a link is exclusively used to deliver only one video clip. On the other hand, buffers and disks are established easier than the links. Moreover, some simulating results are shown. Then, the amount of buffer space is restricted, and disks are used for storing the video in temporal.

1 INTRODUCTION

In recent, videos have been dealt with as primary contents in networked multimedia systems(Dashti, 2000; Hua, 2000). Such systems deliver videos through network structure. Then several kinds of resources are used to achieve this, scheduling of link utilization is one of vital problems for designing the systems.

From the viewpoint of the utilization of restricted link bandwidth, there are two types of methods(Ito, 2004). One is that a video clip is transmitted by using link bandwidth as much as possible; the other is that a video clip is transmitted as little as possible. The former is the method that an entire link bandwidth is used for delivering only one video clip, the latter is that a minimum bandwidth is used. These two delivery methods are called the available bandwidth delivery method and the minimum bandwidth delivery method, respectively.

In the available bandwidth delivery method, an entire link bandwidth is used for transmitting only one video clip. While the video clip is transmitted through a link, this link is exclusively used to achieve this transmission. Also, there is the case that there is difference between bandwidths of two links which are connected to intermediate servers. At an intermediate server, if the link bandwidth of the link used for receiving the video is broader than the link bandwidth for sending it to another server, buffer space is required to store overflowed video.

An algorithm for delivering videos is proposed by (Zhang, 2000). This algorithm treats scheduling of resources which are disk bandwidths and network bandwidths in sense of physical structure. Routing algorithms are proposed by (Vogel, 1996), which satisfy Quality of Services constraints. The method described in (Won, 1999) treats the video placement, and transmission costs of video clips. The method shown in (Shahabi, 2000) deals with transmitting videos and buffering in servers. An entire bandwidth of a link is used for transmitting a video.

This paper is organized as follows. Section 2 presents an overview of a networked video delivery system. An overview of scheduling with buffer restriction and with disks in Section 3. Some simulating results are presented in Section 4. Finally, Section 5 presents some concluding remarks.

2 AN OVERVIEW OF A DELIVERY MODEL

A structural overview of a model for delivering videos is shown in Figure 1 from the viewpoint that a video

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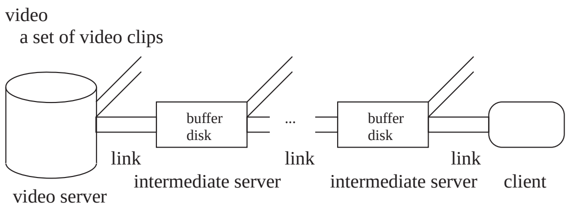


Figure 1: An overview of a networked video delivering system.

is delivered from a video server to a client site. A video server and a client are connected by some links. When a client requests to watch a certain video, the requested video is delivered from the video server to the client site through several intermediate servers. The sequence which consists of a video server, some intermediate servers and a client site, is called a delivery path which is used for delivering a requested video clip. The intermediate server consists of links, a disk and a buffer. The disk is used for storing received video. Stored videos are kept in an intermediate server since the video is removed from the disk. Stored video in the buffers is sent automatically and implicitly, while stored video in disks are arrived and are left explicitly in sense that they are scheduled.

For delivering video, costs are computed. The costs are defined from two viewpoints. One is related to quality of the delivery path in sense of Quality of Services(QoS), another is related to usage costs of resources. These costs are called a quality cost and a charge cost, respectively. The quality cost is specified in failure rate, packet loss ratio, and delay time of intermediate servers and links. The quality costs of paths are computed as the follow expression;

$$\begin{aligned} \mathit{cost}_{\mathit{quality}}(\mathit{path}) = {} & W_{FR} \times \mathit{FailureRate} \\ & + W_{PL} \times \mathit{PacketLoss} \\ & + W_{DT} \times \mathit{DelayTime} \end{aligned}$$

FailureRate, *PacketLoss* and *DelayTime* are QoS parameters. While, W_{FR}, W_{PL} and W_{DT} are their weights.

A charge cost of a delivery schedule is computed as the follow way;

$$\begin{aligned} \mathit{cost}_{\mathit{charge}}(s) = {} & \sum_i C_{\mathit{link}_i} \times \mathit{LinkUsageTime}_i \\ & + \sum_j C_{\mathit{disk}_j} \times \mathit{DiskUsageTime}_j \\ & + \sum_k C_{\mathit{buffer}_k} \times \mathit{BufferUsageSpace}_k \end{aligned}$$

s is a schedule. C_{link_i}, C_{disk_j} and C_{buffer_k} are unit costs for using each link i, disk j and buffer k of a schedule, respectively. Costs of links and disks are charged for their usage times. A unit cost for a buffer is charged to the amount of utilized buffer space.

3 A SCHEDULING METHOD WITH BUFFERS AND DISKS

The policies to construct schedules are as follows;

- An entire link bandwidth is used for delivering one video clip. During this delivery the link is utilized exclusively.
- The first video clip of a certain video leaves from its video server, as soon as possible, if the quality costs of paths are the same.
- The usage of buffers takes precedence over the usages of disks.
- When the disk is used for storing a video temporally, the video is stored into the intermediate server nearby a client than a video server.

Schedules are constructed in the following way. At first, when a request occurs at client site, paths from video servers to the client are obtained for each video clip of a requested video. These paths are called candidate paths for delivering video clips.

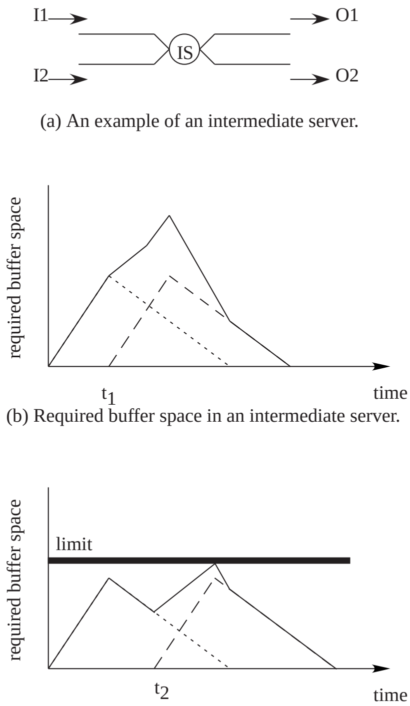
Next, a delivery path is selected among candidate paths by using a certain strategy to decide the delivery path. There are three strategies. They are;

- Departure time effective strategy. The first video clip departures from a video server as soon as possible.
- Quality cost effective strategy. The path whose cost is the lowest among a collection of candidate paths is selected preferentially than others. The quality cost is measured in $cost_{quality}(path)$.
- Score effective strategy. The collection of candidate paths is ordered based on their scores. Scores of the paths are calculated in terms of their quality costs and their initial latency times when candidate paths are used to deliver clips.

Finally, departure times of the consequent video clips of the requested video are computed consequently.

Figure 2 (a) shows a simple network structure, in which there are one intermediate servers IS, and four links, I1, I2, O1 and O2. Let the bandwidth of I1 and O1 are a [Mbps] and b [Mbps], $a > b$, respectively, and a video clip be delivered from I1 to O1, whose size is M [Mbyte]. In (b), the short dotted line shows the required buffer size of the intermediate server. The maximum required buffer size is computed as: *the maximum required buffer size* $= (a - b) * M/a$.

On the other hand, there is the case that an intermediate server is connected to some servers and client

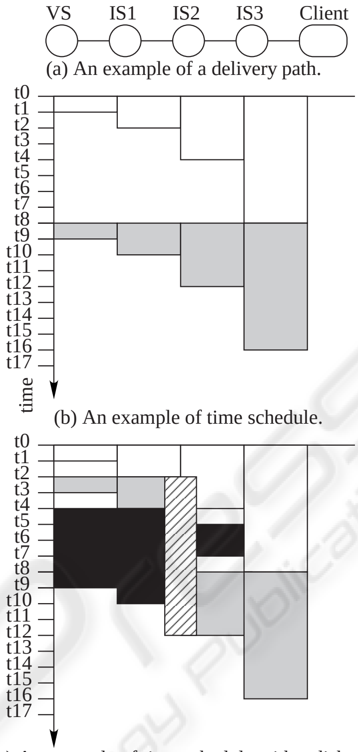


(a) An example of an intermediate server.

(b) Required buffer space in an intermediate server.

(c) Required buffer space in an intermediate server and restricted buffer space.

Figure 2: Required buffer space in an intermediate server and restricted buffer space in the intermediate server.



(a) An example of a delivery path.

(b) An example of time schedule.

(c) An example of time schedule with a disk.

Figure 3: An example of time schedule using disks.

sites. For example, input streams of the intermediate server are I1 and I2, and output streams are O1 and O2, as shown in Figure 2 (a). In (b), a short dotted line and a long dotted line show required buffer size to transmit I1 to O1, and I2 to O2, respectively. Required buffer space for delivering these two video clips is shown in a solid line. If the buffer of the intermediate server is unlimited, these two video clips are able to be delivered. However, if the buffer space is restricted, the arrival time of the clip using I2 and O2 is shifted to t2 from t1 as (c).

The scheduler tries to make a schedule which uses disks, when it is impossible to deliver video clips due to buffer overflow. Figure 3 shows an example of time schedule using disks. A delivery path is shown in Figure 3 (a). This path consists of the video server (VS), three intermediate servers (IS1, IS2, IS3) and the client site (Client). The client requests the video which consists of two video clips. The time schedule which is shown in (b) is constructed in the simplest way. The time schedule for delivering the first video clip is shown in the white squares, the time schedule for the second clip the gray squares, respectively.

Figure 3 (c) shows the time schedule using a disk. Black squares show the region which is allocated for delivering some other videos than the requested video. The first video clip is delivered by the same time schedule shown in (b). However, the second clip is not able to be delivered in the same way shown in (b). Because, the region which is required to deliver the second video clip had been allocated to deliver other clips. In this case, the second video clip is able to be delivered without skew time and without increasing the initial latency time by using the disk which is provided in intermediate server IS2. Also, the scheduler tries to use the disk of IS3, however to use this disk is difficult since the time interval that is required to deliver the clip by the link between IS2 and IS3 is not sufficient for delivering the second video clip.

To prevent the occurrence of skew time, the second video clip has to arrive to the client site by t8. The link between IS2 and IS3 is able to be used for delivering the second video clip. However, the links between VS and IS2 are not used for its delivery. On the other hand, the links between VS and IS2 is able to deliver the clip for [t2, t4]. The video clip which is transmitted using the interval [t2, t4] is stored into the disk of IS2. At t8 this stored video in IS2 is delivered. The client receives the second video clip without the skew time. The striped region of this figure (c) depicts the usage time of the disk in IS2.

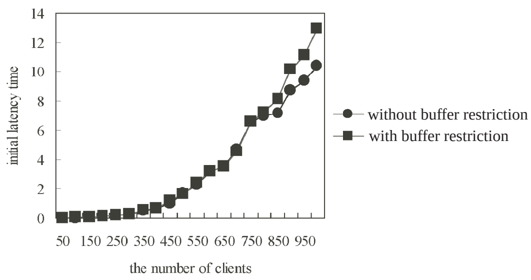


Figure 4: Initial latency time of schedules with buffer restriction.

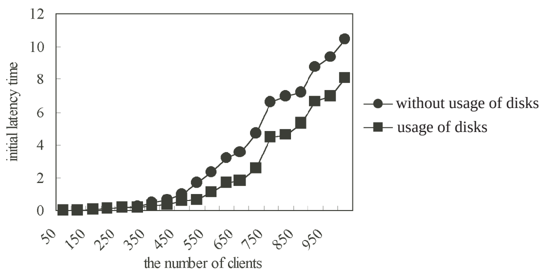


Figure 5: Initial latency time of schedules with disks.

4 SOME SIMULATION RESULTS

Some simulating results are shown by making some assumptions. At fist, the network structure is assumed. There are three video servers, nine intermediate servers, and links connecting servers. Each video server is connected to one intermediate server. Capabilities of links are several tens and/or several hundreds bandwidth [MByte]. The bandwidth of the links between a video server and an intermediate server are several hundreds. The client sites are connected to intermediate servers. Moreover, the size of each video is 40 [MByte]. All videos consist of two video clips whose size is 20 [MByte], and their consuming ratios are 1 [MBps]. These two video clips are stored in the same server. Furthermore, the requests occur during 100 seconds. The request times are generated as uniform random variables.

The initial latency times of some schedules which are made using the departure time effective strategy are shown. Figure 4 shows the initial latency times, in which two lines are shown. They are corresponding to the initial latency times when the buffer space is restricted, and when the buffer space is not restricted. On the other hand, Figure 5 shows the initial latency times whether the scheduler uses disks or not. The initial latency times are reduced by introducing disks. The efficiency for introducing the disks appears although the number of clients is small.

5 CONCLUDING REMARKS

An overview of the method that the full bandwidth of a link is used for delivering one video clip is described. Then, the utilization of buffers and disks are introduced. Now, we plan to extend the capacity of the scheduler from the following viewpoint. Utilization of bandwidths of links makes be more effective. When the bandwidth of an output stream is larger than a bandwidth of an input stream, the link of the output stream is used in partial.

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