A hybrid approach to broadcasting method in Near Video on Demand service for bandwidth-restricted clients

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***Abstract*— In this paper, we propose a new hybrid broadcasting method for bandwidth-restricted clients. The proposed method is called Pagoda-Extended Fibonacci Hybrid Broadcasting (PEFHB) which incorporated Pagoda Broadcasting and Fibonacci Broadcasting. By combining two methods, we reduced the maximum wait time of clients comparing to conventional NVoD methods. Our simulation results showed that PEFHB significantly shortened wait time compared to Greedy Disk Conserving Broadcasting and Extended Fibonacci Broadcasting in the same condition.**

***Keywords*— Multimedia Communication, Broadcasting, DCATV, IPTV, NVoD**

I. Introduction

In the convergence environment of broadcasting and telecommunication, the interactivity between service provider and consumer became important. Video on Demand (VoD) is a typical example of interactive service and demand of the service has been prospected to increase as development of service infrastructure such as Internet, DCATV and IPTV. In addition, consumers recently show a tendency for consuming media when they move. Thus, we can prospect that the request of VoD service in mobile environment will be increased.

In VoD service, server allocates one channel to deliver video data to each client. This transmission method causes a limitation of access to the server by a lack of network resources, i.e. channel bandwidth of server. Near Video on Demand (NVoD) [1] had been proposed to solve the access limitation for popular contents which are highly requested. In the NVoD, server periodically broadcasts video data on designated channels at scheduled time and clients share those video streams. Thus, server can provide VoD service for a huge number of clients with certain bandwidth.

However, existing NVoD schemes such as Fast Broadcasting (FB) [11] and Pagoda Broadcasting (Pagoda) [5], [6] would be inapplicable to mobile environments. In these schemes, clients are required to simultaneously access to the numerous broadcasting streams for continuous playback. When the number of concurrent access (NCA)[1] is large, clients are required to have broad bandwidth. In mobile environment, the large NCA is considered a burden on clients, since the clients usually have limited channel bandwidth. To that end, several schemes have been studied for mobile NVoD [8], [9], which requires small NCA. Among mobile NVoD schemes, Regular/Sub-channel Broadcasting (RSB) [9] is based on Staggered Broadcasting (SB) [2], which broadcasts same video data on dedicated channels with certain delay. RSB has shorter service latency than SB by transmitting the first segment more frequently. In addition, clients need up to two channels for receiving video streams in RSB. Thus, it is applicable to mobile NVoD.

Although RSB reduces the number of channels required at client side, it still has room for improvement in service latency. In this study, we aimed to find a method for mobile NVoD that reduces both the service latency and the NCA to the broadcasting channels. To overcome these drawbacks, we developed a hybrid method, Pagoda-Extended Fibonacci Hybrid Broadcasting (PEFHB) which incorporates the strong point of Pagoda and extended Fibonacci Broadcasting (FiB) [5, 6]. Our simulation result showed that PEFHB significantly reduced the wait time compared to GDC (j=3) [7] and extended FiB. In addition, it was observed that NCA in PEFHB is still lower than conventional NVoD schemes such as FB and Pagoda.

The rest of this paper was organized as follows. In section 2, we developed a hybrid scheme, PEFHB, and consider its NCA. In section 3, we evaluated the performance of the proposed scheme compared to SB, FiB, SkyB [10], GDC (j=3), RSB and

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[1] NCA: the number of concurrent accesses to the video streams in different channels by a client

FSHB. Finally, we summarized key conclusions of this work in section 4.

II. Pagoda- Extended Fibonacci Hybrid Broadcasting : PEFHB

A. Backgrounds

Before designing a new broadcasting scheme, we compared developed methods with three points of view: Wait time, Server bandwidth efficiency, and Number of Concurrent Accesses. It is obvious that NVoD method is superior to RVoD (Real VoD) in server bandwidth efficiency when many clients require the same contents. To compare the server bandwidth efficiency among NVoD methods, we assumed a certain wait time and compared the number of server channels to insure the wait time. In this study, we set the wait time as 30 seconds which is as twice as the length of commercial advertisement in TV. When the total video length is 2 hours in the NVoD which divide the whole data into many segments, the length of the first segment should be 30 seconds to insure the 30 seconds of maximum clients wait time. It means that the total number of segments should be 240 or more. Thus we examined the number of server channels and Number of Concurrent Accesses when the number of whole segments is over 240 at each NVoD methods.

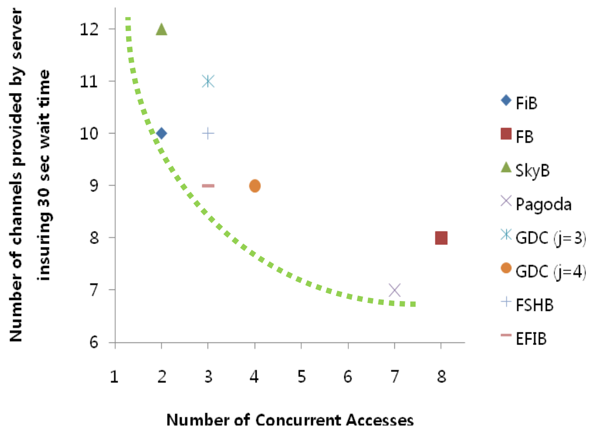

Figure 1. A distribution chart of many NVoD methods and tendency line

Figure 1 shows a distribution chart of each NVoD methods. Note that X-axis represents the Number of Concurrent Accesses and Y-axis represents the number of channels provided by server insuring 30 seconds of client wait time. Generally, the method located the most left-down side of the chart is the best method for all environments. However we can notice a tendency that the number of channels decreases as NCA increases. Thus we need to adapt proper method considering NVoD service environment such as available server bandwidth and bandwidth limitation of clients. When clients are under bandwidth restricted environments such as mobile or wireless network, service provider will choose the method having small NCA and using less number of server channels.

In this study, we assumed that clients can access up to three video streams simultaneously because there are room for improvement near three NCA in Figure 1. Therefore, Methods above three NCA such as GDC (j=4), FB and Pagoda are inapplicable to our environment because of the bandwidth limitation of client. However, all the methods located below three NCA on the distribution chart can be candidates for comparing to proposed method.

B. Design of Broadcasting Structure

Proposed method has hybrid structure of two broadcasting methods. We incorporated Pagoda Broadcasting (Pagoda) and Extended Fibonacci Broadcasting (EFiB). Each method has unique characteristics at data broadcasting structure and data segmentation methods. Pagoda sends video data segments using different sending periods related with their play sequence. EFiB divides video data using extended Fibonacci sequence and allocates segments on the channel as summation of segments for last three channels. We divided video data into many segments and designed a broadcasting structure sending several segments in front part using Pagoda and sending the others using EFiB (PEFHB: Pagoda-Extended Fibonacci Hybrid Broadcasting).

Pagoda uses server bandwidth efficiently because it considers sending period of each video segments. The broadcasting structure leads short wait time of client in Pagoda. However, Pagoda needs k NCA to clients when NVoD server allocates k channels for broadcasting. In our assumption in ***A***, we allowed up to three NCA. Thus PEFHB broadcasts video segments on the first three channels using Pagoda. In Pagoda broadcasting, the total number of segments z using k channels is defined as follows.

$$z = \begin{cases} 4(5^{k/2-1}) - 1 \text{ , where k is even} \\ 2(5^{\lfloor k/2 \rfloor}) - 1 \text{ , where k is odd} \end{cases} \tag{1}$$

From the equation (1), we can calculate that Pagoda broadcasts nine segments ($2(5^{\lfloor 3/2 \rfloor}) - 1 = 2(5^1) - 1 = 9$) using three channels. Therefore, PEFHB broadcast the first nine video segments on three channels using Pagoda.

For the other video segments except the first nine, PEFHB use EFiB for broadcasting. Fibonacci Broadcasting (FiB) has a rule that determine the size of segment (s_{next}) on next channel as the summation of sent segments during previous two channels. Equation (2) describes the rule.

$$s_{next} = s_{current} + s_{current-1} \tag{2}$$

The rule allows to FiB use bandwidth of clients more efficiently and reduces wait time of clients. We can apply the same rule to our environments because FiB requires only two

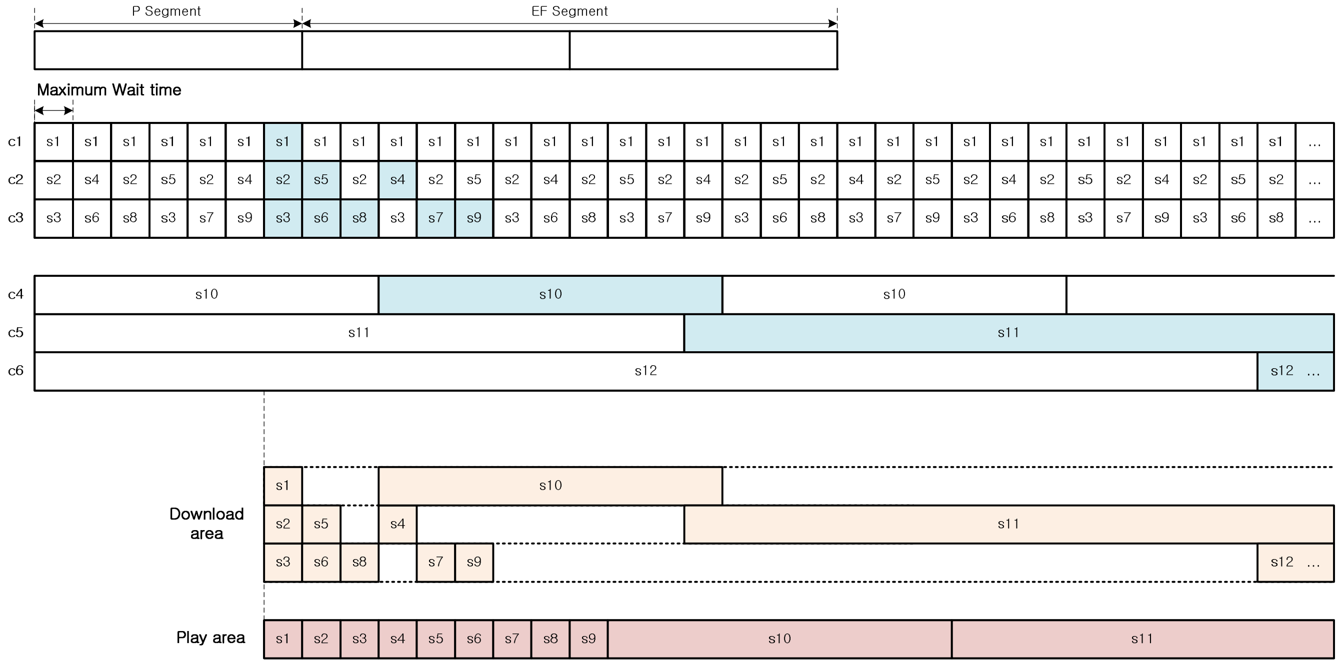

Figure 2. An example of Pagoda-Extended Fibonacci Hybrid Broadcasting (PEFHB) when server allocates six channels to broadcast video streams

NCA. However we extended existing rules to use bandwidth of clients more efficiently. Thus we designed that the size of the segment broadcasted on each channel is determined by the summation of previous three segments' size.

$$s_{next} = s_{current} + s_{current-1} + s_{current-2} \tag{3}$$

PEFHB can reduce the maximum wait time of clients and keep NCA as three by using this rule.

From the segmentation rules we have discussed, we can calculate the total number of video segments. Table 1 shows the total number of video segments respect to the number of channels provided by NVoD server.

Table 1. Total number of video segments respect to the number of channels provided by NVoD server

k	1	2	3	4	5	6	7	8
# of video segments	1	3	9	18	35	67	125	232

Thus, we can represent the maximum wait time of client in PEFHB as follows.

$$w_{\max\_PEFHB} = \frac{L}{\sum_{j=1}^{k} a_j} \tag{4}$$

$$\text{where, } a_1 = 1,\ a_2 = 2,\ a_3 = 6 \text{ and } a_j = \sum_{i=j-3}^{j-1} a_i$$

From what we have discussed, we can determine the broadcasting structure of PEFHB. Figure 2 shows an example of broadcasting structure of PEFHB when server allocates six channels for NVoD service.

III. Simulation Results and Discussion

To examine the performance of PEFHB, we compared the wait time of the three methods; GDC (j=3), EFiB, PEFHB. In an NVoD application, the wait time can vary depending on the request point of each client. In other words, clients can have different wait time in the same NVoD application. To compare their performances, we set the worst case in which clients wait the maximum time in each NVoD application. Figure 3 shows the simulated maximum wait time for each method with respect to the number of channels provided by NVoD server.

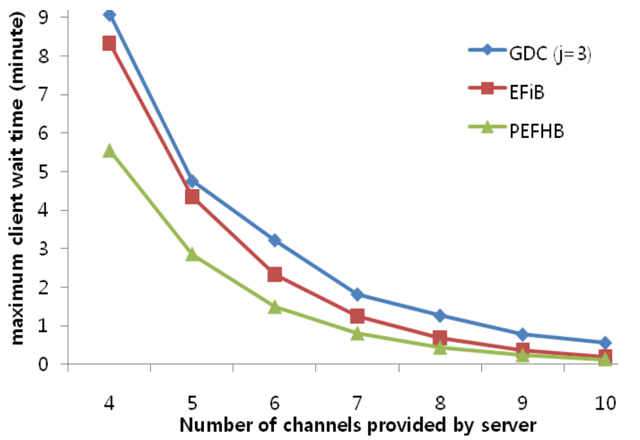

Figure 3. Simulated maximum wait time for GDC (j=3), EFiB and PEFHB with respect to the number of channels provided by server

Note that we set the total video length L=100 (min) and all clients has bandwidth three times larger than video stream rate.

In Figure 3, PEFHB has the shortest wait time when server allocates more than four channels for NVoD service. To see the result more specifically from k=7 to k=9, we can convert the result from minute domain to second domain. The wait time had calculated when the video length L=100 (min). Thus, we can regard this result as a wait time ratio to the total video length. Then, we converted the result when L=120 (min) and table 2 show the results represented as second domain.

Table 2. Wait time comparison among GDC (j=3), EFiB and PEFHB when k=7, 8, 9

Unit: sec	GDC(j=3)	EFIB	PEFHB
k=7	130.9	90	57.6
k=8	91.1	48.6	31.0
k=9	55.8	26.4	16.8

In table 2, when server allocates eight channels, the maximum wait time of GDC (j=3), EFiB and PEFHB is about 91.1, 48.6 and 31.0 (sec), respectively. In the same condition, PEFHB reduced the wait time about 36.2% and 66% compared to EFiB and GDC (j=3), respectively. In addition, PEFHB shortened the wait time about 36.3% compared to EFiB and 69% compared to GDC (j=3) when k is equal to nine. Thus wait time reduction ratios of PEFHB to two other methods increased as server allocate more channels for broadcasting.

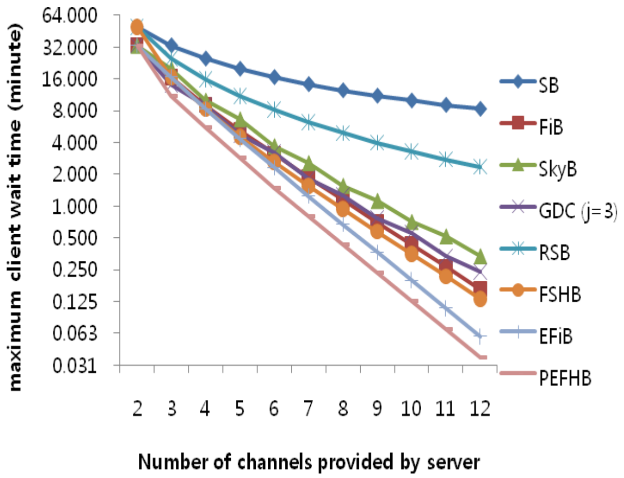

Figure 4. Simulated maximum wait time for SB, FiB, SkyB, GDC, RSB, FSHB and PEFHB respect to the number of channels provided by server (log scale)

Figure 4 shows the maximum wait time comparison among SB, FiB, SkyB, GDC (j=3), RSB, FSHB and PEFHB. Some methods shows large difference of maximum wait time compared to the other methods. Thus, we represented the wait time as log scale to see in a graph. Note that we set the total video length L=100 (min) and clients has bandwidth three times larger than video stream rate. As we can see in Figure 4, PEFHB shows the shortest client wait time among the other methods when server allocates more than three channels to broadcast video streams.

IV. Conclusion

In this study, we have proposed a hybrid broadcasting method in Near Video-on-Demand service for bandwidth-restricted clients. To compare the maximum wait time and NCA at once, we used a distribution chart of many NVoD methods. Then we assumed a circumstance that clients can access up to three streams concurrently and designed a new broadcasting method for the environment. Proposed method is incorporated with Pagoda and EFiB. By examining the wait time comparison to SB, FiB, SkyB, Pagoda, GDC (j=3), FSHB, and EFiB, we evaluated its performance. PEFHB shows the shortest wait time among the other methods in simulation results.

Proposed PEFHB method has an advantage in NCA compared to Fast Broadcasting and Pagoda Broadcasting. Thus, NVoD service can be easily adapted to clients because of eased bandwidth limitation. Service provider can also increase the quality of service using PEFHB owing to its reduced maximum wait time. Therefore, PEFHB would be an efficient solution for NVoD service in bandwidth restricted environment.

As developing technology of memory device, clients can have lager memory than before. However, it is still arguable about the proper amount of buffer size required in NVoD methods. Further study in this filed, it is necessary to design a buffer saving method at client side.

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