A Load Balanced PC-Cluster for Video-On-Demand Server Systems

Liang-Teh Lee[1], Hung-Yuan Chang[1,2], Der-Fu Tao[2], and Siang-Lin Yang[1]

[1]Dept. of Computer Science and Engineering, Tatung University, Taipei, Taiwan
[2]Dept. of Electronic Engineering, Technology and Science Institute of Northern Taiwan, Taipei, Taiwan
ltlee@ttu.edu.tw, {hychang, tftao}@tsint.edu.tw, and g9506031@ms.ttu.edu.tw

Abstract. Video-on-demand (VOD) is one of the hottest and the most potential services of the broadband network applications. In order to offer the video-information service to numerous users nowadays, in this paper, a load balanced PC-Cluster for the VOD server system has been proposed. We adopt Two-Tier model in the systematic architecture, and use the PC-Cluster to be the storage system of the VOD server. The load balancing mechanism is based on the Least-Connection-First algorithm. Furthermore, a video placement strategy is also proposed in this paper to share and balance the loads among video servers in the cluster. Accompany with the dynamically adjusted files in each video level, a dynamically cyclical video replacement mechanism has been proposed to replicate and allocate video files for improving load balance of the system. The experimental results show that a better load balance of the system can be achieved by applying the proposed scheme.

Keywords: Video-on-demand (VOD), PC-Cluster, Load balance

1. Introduction

Because of dynamically audio-visual information in the developed process of multimedia [1, 2], the information is usually transported with huge amount of data, such as, video data. But according to the factor of network bandwidth, it restricts by development. Then, we integrate multiple mechanisms into load balanced PC-cluster server system which can share the load of incoming requests by an equitably distributed scheme. We adopt Two-Tier model in the systematic structure, and use the PC-cluster to be the storage system of the VOD server in order to reach a better scalability. The load balancing mechanism is based on the Least-Connection-First algorithm. We propose a video placement strategy to share and balance the loads among video servers in the cluster. In video level algorithm, videos are classified into three categories according to the popularity of the video. In video placement mechanism, video files are replicated to different amount of copies according to their levels, and these replicas are distributed to other video servers by the duplicated mechanism of Chained-Declustering [3, 4]. In this paper, a dynamically cyclical video replacement mechanism has been proposed to replicate and allocate video files for improving load balancing of the system so as to obtain a better performance of the load balanced system.

2. Related works

PC-cluster system [5] built in 1994; Beowulf is a class of computer clusters similar to the original NASA system. Load balancing [6] in the network is the use of devices external to the processing servers in a cluster to distribute workload or network traffic load across the PC-cluster. The live load balancing server receives incoming requests, monitors the load and available system resources on the Back-End servers, and redirects requests to the most appropriate server. The common used balancing methods in PC-cluster system are described below: 1.Round-Robin algorithm: Assigning the next incoming requests to the next video server in order and rotates through the order continuously for further requests. 2. Weight algorithm: Calculating a weight value by current workload and condition of video server. 3. Least-Connection-First algorithm: Load balancing server keeps track of all currently active connections assigned to each video server in the cluster and assigns the next new incoming connection request to the video server that currently is the least connections.

Video duplicated mechanism is to copy the same file in different number of replicas that are stored in different disks. Two different video duplicated mechanisms are introduced below: 1. Mirroring: The file of disk is completely copied and directly allocated to the corresponding disk. 2. Chained-Declustering: The duplicated file is allocated by the displacement-linked way, as shown in Fig. 1.

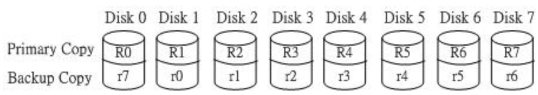

Fig. 1. Chained-Declustering

3. System architecture and video strategy

The Two-Tier model [7, 8] of the proposed scheme is shown in Fig. 2. All of servers in the system use real IP to connect the Ethernet, but the system only provides IP address of load balancing server as a unified communication channel. Servers are responsible for the work as described below:

1. Load balancing server: Responsible for sending and receiving RTSP [9, 10] packets between client and video servers. Responsible for load balancing method. Include

video information database with serving video states in each video server and connecting load information database with currently load states in each video server.

2. Video servers: Sending video information with serving video states in each video server to load balancing server and stored video files.

The load balancing algorithm adopted in the proposed system is combining Least-Connection-First with Round-Robin. Since videos are always increased and removed in the PC-cluster VOD system, the Chained-Declustering is applied to allocate duplicated video files.

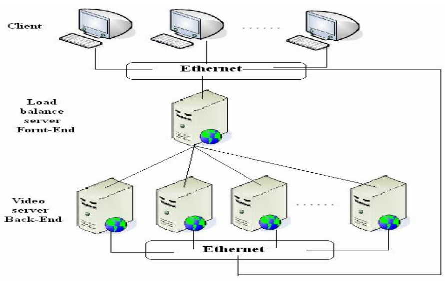

Fig. 2. Two-tier architecture

A series of the video placement strategies is applied in the proposed system, that is, video level algorithm, video placement mechanism, and video replacement mechanism. Figure 3 is the flow chart of video placement strategy. First, according to the video level algorithm, videos are classified into three categories, hot video, normal video, and low video. Then, according to different level of videos, the system copies different number of video files to video servers. As video levels in the system are altered for the click numbers, they will be dynamically adjusted. There are three video replacement modes, hot to low, normal to hot, and low to normal, and video categories are adjusted dynamically.

According to different probability of connections and video categories, video files are allocated. According to click rates of videos, different video levels will have different probability of connections. The click rates of video levels are defined as follows: Hot videos: The front twenty percent of click rate, Normal videos: The front twenty to eighty percent click rate, Low videos: The lastly twenty percent of click rate. By using PC-cluster VOD system for load balancing, we assume that each video file is stored in two different video servers. Table 1 presents the parameters used for video placement mechanism. Suppose the system is constructed by six video servers with 75G hard disk size of each video server, averagely each video size is 1GB, and total hard disk size is 450G. Thus, the system should consist of 450 video files. If each video is stored in two different video servers, total number of video files will be 225. According to the video level algorithm, i.e., HVR: 20%, MVR: 60% and LVR: 20%, the number of files in each video level of the proposed system will be: Hot video number: 225 * 20% = 45, Normal video number: 225 * 60% = 135, Low video number: 225 * 20% = 45.

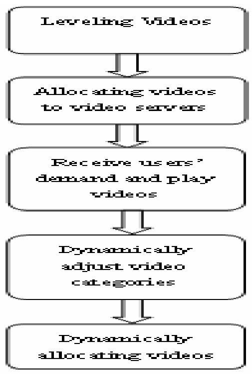

Fig. 3. The flow chart of video placement strategy

Table 1. The parameters used for video placement mechanism

Parameters	Name
Number of Video Server (Back-End)	*BN*
Hard Disk Size of Each Video Server (Back-End)	*BS*
Average Video Size	*VS*
Total Number of Videos in the System	*VTN*
High_Videos Rate	*HVR*
Normal_Videos Rate	*NVR*
Low_Videos Rate	*LVR*
High_Videos of Hard Disk Occupied in Each Video Server	*HVSR*
Normal_Videos of Hard Disk Occupied in Each Video Server	*NVSR*
Low_Videos of Hard Disk Occupied in Each Video Server	*LVSR*
Total Number of High Videos in the System	*HVTN*
Total Number of Normal Videos in the System	*MVTN*
Total Number of Low Videos in the System	*LVTN*

Duplicated number of level video files:

- Hot video: High click rate. The number of duplication is defined as $\mathrm{Bs}/2 = 3$.
- Normal video: The number of normal video files duplicated is calculated by considering the total number of video files expected, including replicas, and the hard disk space occupied by hot and low video files. Total number of normal video files, including replicas, in all video servers can be calculated as: $M\mathrm{V}_{TN} = B_S * \mathrm{NV}_{SR} / \mathrm{V}_S * B_N$ Since original number of normal video files in all video servers is $\mathrm{V}_{TN} * \mathrm{NV}_R$ The number of duplicated normal video files can be expressed as: $\lfloor M\mathrm{V}_{TN} / \mathrm{V}_{TN} * \mathrm{NV}_R \rfloor$ The percentage of hard disk occupied by three level video files in each video server is assumed as: the HVR is 20 percent, the HVSR is set to 30 percent, the NVSR of normal videos is set to 60 percent, the LVR is 20 percent, and LVSR is set to 10 percent. Consequently, according to the above analysis and assumptions, the number of duplicated normal video files calculated as $\lfloor 75*0.6/1*6/225*0.6 \rfloor = 2$.

- Low video: The number of duplicated videos calculated as $\lfloor 75*0.1/1*6/225*0.2 \rfloor = 1$

Original and total number of files in each video level is shown in Table 2. Accompany with the dynamically adjusted files in each video level, a dynamically cyclical video replacement mechanism has been proposed to replicate and allocate video files. There are three video replacement modes in the proposed scheme, such as low to normal, hot to low and normal to hot. Figure 4 is the operational process of video replacement mechanism. For example, there are twelve video files in below system. The operational process in step by step is described as follows: 1. Sort the click number of all original videos by decreasing order. 2. Sort the click number of all newly videos by decreasing order. 3. Compare with allocation of sorted order. If the allocation of original video is not equal to newly video, they will be swapped allocation by themselves. 4. They are modified their categories and copied appropriate video files to store in the corresponding video server.

Table 2. Original and total number of files in each video level

	Original number	Total number
Hot video	45	135
Normal video	135	270
Low video	45	45
Sum	225	450

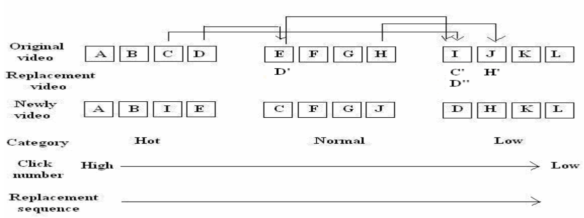

Fig. 4. The operational process of video placement mechanism

4. Experimental results

The proposed video placement strategy is applied to allocate video files, and users' connections and click number of videos are simulated. Table 3 shows the tested video information. Fast Ethernet with the highest bandwidth is 100Mb/s. In the simulation, the bandwidth of the internet is considered as 80Mb/s. Thus, the maximum of each video connection is $\lfloor 80 * 1024/1553 \rfloor = 52$.

The proposed system, Least-Connection-First with Chained-Declustering, is comparing with three other systems, i.e., Round-Robin with Mirroring, Round-Robin with Chained-Declustering, and Least-Connection-First with Mirroring. The connection probabilities of different video categories used in the experiments are listed in Table 4. Figure 5 shows the comparison of the maximum number of video connections among the proposed system and three other systems. As the result, the proposed system can support more than two times of the maximum number of video connections in comparing with three other systems. Figure 6 is the comparison of utilization of each video server among the proposed system and three other systems when each system is overloaded.

Table 3. The tested video information

Length (minute)	Resolution	File size (GB)	Avg. bit rate(Kb/s)
90	640x480	1	1533

Table 4. The connection probabilities of different video categories

Video category	Connection probability	Connected number	Cycle	Video number
Hot	5/9	5	3	1~23
			2	24~25
Normal	3/9	3	2	1~68
			1	69~135
Low	1/9	1	1	1~45

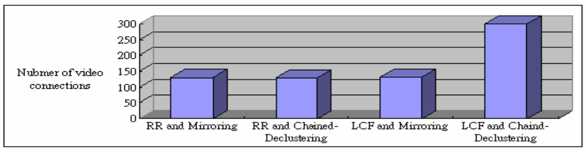

Fig. 5. The maximum number of video connections

A dynamically cyclical video replacement mechanism has been proposed to replicate and allocate video files for enhancing load balance of the system. We assume the levels of video files are adjusted as follows: 1. Hot to Low: Twenty hot videos are selected randomly to be adjusted to low videos. 2. Normal to Hot: The front twenty normal videos are adjusted to hot videos. 3. Low to Normal: The front twenty low videos are adjusted to normal videos.

We assume that if a video in the front twenty hot videos is requested, then that video will be requested two more times. Figure 7 is the comparison of the maximum number of video connections for the proposed system without and with applying replacement mechanism. Figure 8 is the comparison of the utilization of total video connections and total video files used for the proposed system without and with applying replacement mechanism. For comparing the maximum number of video connections, the system with applying replacement mechanism will be slightly better than that of the system without applying replacement mechanism according to total video files used. In the proposed system, video file levels are adjusted dynamically and a dynamically cyclical video replacement algorithm is applying to replicate and allocate video files for supporting more connections for all video files. Thus, the system with applying replacement mechanism will maintain almost constant utilization of video servers and maximum number of video connections, even if the connection probabilities of some specific hot videos are higher than other videos.

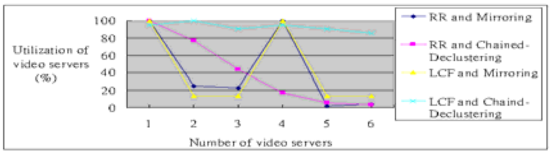

Fig. 6. Utilization of each video server

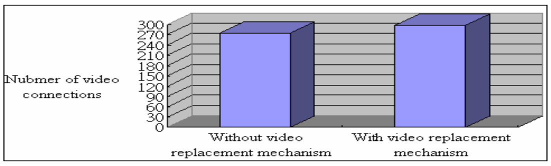

Fig. 7. Comparison of the maximum number of video connections for the proposed system without and with applying the replacement mechanism

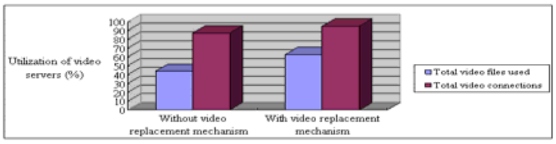

Fig. 8. Comparison of the utilization of total video connections and total video files used for the proposed system without and with applying replacement mechanism

5. Conclusions

In order to support more efficient and offer the video-information services to numerous users, a load balanced PC-cluster for the VOD server system has been proposed. According to Two-Tier model and Least-Connection-First algorithm with a series of the video placement strategies, an efficient load balance system can be achieved by applying the proposed mechanism. Accompany with the dynamically adjusted files in each video level, a dynamically cyclical video replacement mechanism has been proposed to replicate and allocate video files for improving load balance of the system.

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Authors

Liang-Teh Lee is the Professor of the Department of Computer Science and Engineering, Tatung University. His research interests include computer architectures, parallel and distributed computing, embedded systems, and high speed switching architectures.

Hung-Yuan Chang is the Senior Lecturer of the Department of Electronic Engineering, Technology and Science Institute of Northern Taiwan and the Ph.D. candidate in Computer Science and Engineering from Tatung University. His research interests include task schedule, parallel and distributed systems.

Der-Fu Tao is the Associate Professor and Chairman of the Department of Electronic Engineering, Technology and Science Institute of Northern Taiwan. His research interests include parallel and distributed systems, embedded systems, and architecture design of high speed switching system.