STB Based Multimedia Information Publication System

Xuan Li
School of Software, Fudan University, Shanghai 200433, P.R.China
Email: 082053002@fudan.edu.cn

Lixin Lin¹, Xin Liu¹, Dejian Ye¹ and Weihui Dai²
¹School of Software, Fudan University, Shanghai 200433, P.R.China
²School of Management, Fudan University, Shanghai 200433, P.R.China
Email: 082053024@fudan.edu.cn, xinliu@fudan.edu.cn, dajianye@fudan.edu.cn, whdai@fudan.edu.cn

Abstract—The development of communication network has promoted the development of network multimedia. Nowadays, multimedia information can be displayed in various ways. Therefore, an efficient publication system is very necessary for users to distribute and display multimedia content fast and efficiently. To satisfy user’s requirement, the set-top box (STB) based multimedia publication system is designed and implemented. The STB based system proposed in this paper adopted distributed B/S architecture, which is reasonably divided into five modules according to their own functions, consisting of information center, sharing database, time-sharing distribute engine, group controller and STB terminals. The performance and flexibility of this framework is very favorable. Its control logic is separated from physical time-sharing data transmission, in order to improve scalability and reliability. Data transmission is optimized to support a large number of terminals with special algorithms. Time-sharing engine is used to improve robustness of system when sources exceed the capacity of STB. Evaluation result shows that the system designed in this paper can provide high-quality information display services for terminal users with a relative low hardware cost. The kind of information publication system has been applied in retail stores, restaurants in Shanghai, Beijing and Nigeria.

Index Terms—multimedia display, time-sharing distribute, information publication

I. INTRODUCTION

With the rapid progress of society, the increasingly fast development of network and the wider and wider usage of information publication systems day by day, the necessary and efficiency of multimedia information display in people's lives is becoming more and more important. The publication systems, which can quickly and efficiently distribute multimedia in public places, have proved to be user’s urgent needs [1].

Multimedia information publication system, such as taxi video advertisement displaying system and advertisement displaying system in other public places, which is a combination of software and hardware, can publish all kinds of multimedia information in a special layout style and then display them on the electronic screen system. Multimedia Information publication system often uses rich kinds of interactive modes, which not only accelerates the speed of passing on information and promotes system efficiency, but also it expands the scope of staff knowledge.

As the time going by, the traditional web information publication systems have exposed many problems under practical test. In the logic aspect, the business layer mingling with data layer make the system highly coupled, which is difficult to modify and maintain; in the functional aspect, the type of multimedia information supported by the system is very simple and constrained, which only contains simple text and some basic pictures. Even worse, those simple media information only can be displayed in just several ordinary forms.

CWHKT [2] is a commercial video information publication system, which adopts integrating the central server with each subsystem in its first design. Although CWHKT is currently a good video information distribution system operating pretty well, its cost of maintaining and operating is very large, which leads to that CWHKT could not be applied to a wide range of coverage. Based on worry of cost and flexibility, we refer to foreign leading information publication system, Net Key/Web Pavement [3], which takes the set-top box (STB) as a display terminal and uses web platform as user interface. For the reason that the terminal STB is weak, when the coming data reaches a certain level, STB’s ability of dealing with it will reduce significantly and result in response of STB is delayed and finally affect the effect of displaying media [4]. Moreover, with the number of terminals increases and contents continuously updated, the system response speed reduces and user experience will be significantly poor. According to two deficits mentioned above, this paper proposes a solution: Adopting time-sharing mechanism to reduce the amount of media transferred one time to promote robustness and scalability of system. The multimedia system proposed in this paper not only supports various forms of media, such
as video, music and weather components, but also allows kinds of media to be displayed in a particular form of layout on the screen. Moreover, the multimedia publication system adopts Struts and Hibernate framework, departing logic layer from data layer, in order to make the whole system lowly coupled, and then the system is more facilitated to be maintained and expanded later. Finally, the system uses time-sharing distribution policy to ensure performance of system.

This paper firstly describes structures of early systems, and sums up their shortcomings. At the end of part one, paper points out development trends of information system. Secondly it proposes the design criteria as well as functional needs of publication system. Thirdly, the paper depicts the system structure and functionality of its key modules. In the fourth part, the paper mentions function flow of media system and theory and algorithm used in time-sharing distribute engine (TSDE). In the fifth part result test is showed in this chapter. Finally it concludes the characteristics of the system and the outlook for future work.

II. RELATED WORK

A. FIDS

FIDS (Flight Information Display System) [4], which has been applied to Guangzhou BAIYUN International Airport, is a set of information systems that supports to display the combination of airplane and other public information. Multiple media can be displayed in different forms of layout through FIDS. As the system has only been used within the airport, where terminals located relatively concentrated, FIDS adopts both C/S structure and combines central server with PC subsystem module to achieve the effects of displaying better, higher real-time, network overhead lower than B/S. However, due to adopting combination of PC subsystem module, the system is highly coupled, which results in increasing maintenance costs.

B. SIPS

SIPS (STB Based Scalable Information Publication System) [5] are a distributed system that widely used in major cities in China. SIPS can support multiple media formats in accordance with custom layouts with high flexibility, simple and efficient control process. SIPS information center (IS) manipulates only some small amount of metadata, such as STB configuration, program lists and so on. Other information with large amount of data, such as data interacting with STB, STB’s heart records and media source files, is handled by the group controller (GC). For the reason that three key components, information centers, group controller and the set-top boxes are distributed, communication among them relies on networks delivering a lot of interactive information. SIPS requires network having the character of relatively high performance and stability. In the case of wireless networks, SIPS’s performance will be greatly reduced. At the same time, STB’s ability of data processing easily becomes a system bottleneck because it is weak terminal.

When controller sends a packet of program lists with media data reaches a certain degree, the response time of STB would be seriously reduced, which leads to a sharp decline in the processing performance of set-top box or even collapsing. At last, the overall system performance will be seriously affected.

C. 3D Publication System

Nowadays, 3D publication system using B/S mode is very popular not only because B/S mode has good flexibility, security and scalability but also because 3D is a hot item recently. The greatest advantage of system is that system supports 3D model. System uses Cuit3D technology to display the 3D model, which both broadens the meaning of traditional media and provides users with some more choices. Because 3D model needs more system support than traditional information publication system, some optimizing mechanisms must be used to accelerate the speed of system. However, the system mentioned in [11] does not have any optimizing mechanism, which will pull down the system performance and result in the 3D existing only in name.

III. SYSTEM DESIGN

This chapter summarizes the performances and functional requirements of a well designed information system based on STB, referring to several studies of existing systems, and then it proposes reasonable design criteria according to some actual requirements.

A. Characters and Requirements

Multimedia information publication system with STB as the terminal is widely used in many fields. As a new form of media display platform, information system not only provides merchants a stage to advertise and display themselves but also supplies users a new form of information acquisition. So the system should have the following characteristics [12] [13]:

1. System must have a good scalability for adding new function in future [14].
2. System must be low coupled and cost effectively to be maintained and deployed [15].
3. System must have mechanism to guarantee STB’s performance, because STB’s ability of data processing easily becomes a system bottleneck.
4. System can display variety type of media in pre-designed layouts.
5. System must be easy to manipulate that means the process of publishing media is simple and have a good user experience.
6. MVC pattern must be used in web sub-system to separate the data from user interface.

B. Design Criteria

According to the characteristics and requirements of publication system mentioned above, this article proposed some design criteria, both in term of system architecture and component’s functionality. Fig. 1 shows the framework of this system.
In the first place the entire structure of the system is a distributed B/S application system architecture and the system is divided into five major function modules in detail: information center (IC), group controller (GC), time-distribution engine (TSDE), shared database (SD) and terminals(STB). The reason why the system adopts TSDE to analyze program data before sending it is that TSDE helps to reduce STBs’ pressure for data processing. Meantime, STB succeeds in displaying media in variety of forms with embedded browser IPANEL [6] through combining the three technologies, HTML, CSS and JavaScript.

The overall structure of system is distributed which can effectively reduce system coupling among modules to enhance system scalability and reduce the cost of post-deployment and maintenance. IC and GC modules communicate through a shared database rather than the form of directly transmission through network, which are more conducive to synchronize information between various modules.

TSDE distributes media data in accordance according to the order of play time in program list, which helps to not only guarantee the same program list not to be sent for second time but also ensure the data transmitted to STB is under STB’s capacity of processing it.

IV. SYSTEM IMPLEMENTATION

A. System Architecture

As mentioned in chapter three, information publication system based on STB is a distributed system using B/S system architecture [10]. The whole system is divided into five core parts: information center (IC), group controller (GC), time-sharing distributes engine (TSDE) and terminal (STB). Fig. 2 shows the detail architecture of system.

Information Center is an integration of user operation interfaces, user management mechanisms and the set of event triggers. It first provides a flexible and easy interface for user. Media information can be released through the web interface, which simplifies the process of operation. Secondly, IC maintains the core data of user through Hibernate ORM module. Hibernate is a kind of popular cross-platform framework during recent years. It can provide encapsulation of relational database and set up caching mechanism to reduce the number of database queries times to improve efficiency of object processing [7]. When trigger in IC is activated, system automatically generates program lists in format of XML based on user specification and passes program lists to TSDE as input of TSDE.

After getting the command from IC, TSDE starts to analyze XML program lists. When required media sources in program lists exceed the capacity of STB, TSDE will firstly divide program lists into multiple sub-program lists named as time-sharing program lists (TSPL) according to real capacity of STB and secondly, assign TSPL priorities based on their playing time of program. Finally, TSDE saves TSPL into shared database replacing original one.

Control center obtains the control orders issued by IC by scanning the shared database. According to IC’s command, GC pushes media sources required in TSPL to STB.

TSPL is mapping lists from minimum playing time to media name. STB is responsible for maintaining the cache of recently played media [8]. STB reads TSPL as input, when TSPL comes with new media file, STB will update the local file cache according to the recently used strategy. When the media file is ready and play event is triggered, STB will first draw out the customizing layout...
of information as the display background, and then put media programs in the designated area. Media files start rendering and preparing to play after being initialized by STB. The multimedia information publication system described in this paper is fully designed with some basic functions and its publishing process is very simple and easy to use. The system contains more than eight core modules that are user management, layout design, media uploading, media releasing, program list analysis and media file requesting and so on. Fig. 3 shows the functional flow of the information publication system based on set-top box. In media system, publishing media will go through three main stages: program editing, program analysis, media publishing. During program editing stage, administrator firstly designs layouts with which media file is display through web user interface in IC and then uploads media files and saves media information in database. In the end, system according to specification of administrator generates program list and saves it into the shared database.

In phase of program analysis, when the time trigger is activated, time-sharing distribute engine begins to analyze program list generated in program editing stage. If the media sources exceed STB’s capacity, program lists will be divided into TSPLs. In the first time, TSDE finds the key program list by means of core algorithm, and then divides the key program list into multiple TSPLs until TSPLs can be delivered to STB without affecting the performance of system. TSDE also assigns priority to each TSPL on basis of playtime sequence and then stores them into database. During media releasing, group controller obtains commands from information center. Through analyzing the command parsed by, GC confirms the aimed set-top boxes. Then, GC pushes layout information and media files in TSPL from SD to aimed STBs. In the process of data delivering, GC sorts TSPLs according to their priorities. After sorting, GC waits until playtime of TSPL reaches. Then GC pushes all information needed to STB to guarantee STB’s performance. After receiving program information, STB initializes all the media files and layouts, and then the display of program begins.

B. Distribute Theory

In the system designed in this paper, TSDE is newly introduced and used in the process of program analysis for decomposition of program lists into TSPLs according to resource consumption of STB. And TSDE is very important during practical deployment since program lists in real world are usually designed very large and sources of them will exceed the capacity of STB significantly. Without TSDE, STB is likely to stop displaying media except restarting it. The crucial factor in the TSDE is found out the key program list.

<table>
<thead>
<tr>
<th>Media Publish</th>
<th>Information Center</th>
<th>Time-sharing Distribute Engine</th>
<th>Shared Database</th>
<th>Group Center</th>
<th>STB Terminal</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td>Program Sched</td>
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<td>Program Analy</td>
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<td>Program Obj</td>
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<tr>
<td>Media</td>
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<tr>
<td>Layout Design</td>
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<tr>
<td>Upload Media</td>
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<tr>
<td>Program Prereq</td>
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<tr>
<td>Trigger Active</td>
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<tr>
<td>Program List</td>
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<tr>
<td>Program List Analysis</td>
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<td></td>
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<tr>
<td>Playtime reached</td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Select STB</td>
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<tr>
<td>Path Det To STB</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Initialize Media</td>
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</tr>
<tr>
<td>Display Media</td>
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</table>

Figure 3. Functional flow of publication system.
For key program list, TSDE will deliver media file only when the play time of its TSPL reached. TSDE through core algorithm can reduce the amount of media data sent one time and also reduce probability of STB becoming the bottleneck of system. Time-sharing distribute algorithm refer to the fact that resources consumption is different for different type of media. The amount of resources consumption for each type of media is listed in the above table.

According to their definition, we know:

$$C_{ALL} = \sum_{i=1}^{N_S} C_{Si}.$$  

Equation (1) means that total real resources consumption in process of publishing media equals sum of consumption for all program lists sent by GC.

$$C_{Si} = C_{Vi} + C_{MI} + C_{PI} + C_{WI} + C_{TI}.$$  

According to definition of parameters, we can obtain that total real resources consumption in process of publishing media equals sum of resources consumption for all kinds of media type in program.

When replacing $C_{Si}$ with (1), we obtain the complete equation of real resources consumption of program list. The equation is as followed:

$$C_{ALL} = \sum_{i=1}^{N_S} (C_{Vi} + C_{MI} + C_{PI} + C_{WI} + C_{TI}).$$  

Then according to (1) and (2), we can obtain the result (3). Now let’s think about the condition in which the terminals cannot display fluently. When resources consumption reach a level, STB cannot allocate spare memory or CPU for media files. Then the quality of media display is affect. So the condition is:

$$C_{ALL} \leq Q_{STB}.$$  

By replacing $C_{ALL}$ with (3) we get the final condition that is:

$$\sum_{i=1}^{N_S} (C_{Vi} + C_{MI} + C_{PI} + C_{WI} + C_{TI}) \leq Q_{STB}.$$  

STB can display media without carrying about its resources consumption when (5) is satisfied and media can be well displayed with high quality.

In the case of (5) is not satisfied, TSDE will adopt distribute algorithm and select key program list. We will discuss some key program lists and the core algorithm in next section.

C. Key Program and Distribute Algorithm

As the above section said, when (5) is not met, in order to ensure system stability, TSDE will analyze all program list to find out the key program list and then decompose it. To achieve most optimal result in decomposition process of program list, the principle of finding out the key program list is maximizing usage of STB under the condition that STB can play media fluently.

The definition of $K_S$ is as following:

Define $S$ as a set of program lists sent by GC and $S = \{s_1, s_2 \ldots s_n\}$. Define $K$ as a set of key program lists. $s_k \in K$ if and only if subset $S - s_k$ satisfies (4) meaning:

$$\sum_{i=1}^{N_S} C_{Si} - C_{Sk} \leq Q_{STB}.$$  

The key program list is:

$$K_S = Min(K).$$  

Equation (7) means is $K_S$ a program list in $K$ and it consumes the least resources of STB during process of initialization.

After obtaining $K_S$ from (7), it will be divided into $n$ small parts which are $K_{S1}, K_{S2} \ldots K_{Sn}$ . Only if the video in $K_{Si}$ is going to play, GC will send media files and layout to STB. Time-sharing distribution mechanism ensures set-top box not to be fully occupied by many resources. So, TSDE improves the robustness of the system efficiently.

The pseudo-code of our key program algorithm and time-sharing distribute algorithm appears in Fig. 4 and Fig. 5.

<table>
<thead>
<tr>
<th>Notation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_{Vi}$</td>
<td>Resources consumption of video in the $i^{th}$ program list.</td>
</tr>
<tr>
<td>$C_{MI}$</td>
<td>Resources consumption of audio in the $i^{th}$ program list.</td>
</tr>
<tr>
<td>$C_{PI}$</td>
<td>Resources consumption of picture in the $i^{th}$ program list.</td>
</tr>
<tr>
<td>$C_{WI}$</td>
<td>Resources consumption of text in the $i^{th}$ program list.</td>
</tr>
<tr>
<td>$C_{TI}$</td>
<td>Resources consumption of trigger in the $i^{th}$ program list.</td>
</tr>
<tr>
<td>$Q_{STB}$</td>
<td>Threshold of STB</td>
</tr>
<tr>
<td>$C_{Si}$</td>
<td>Total Resources consumption of media in the $i^{th}$ program list</td>
</tr>
<tr>
<td>$S_i$</td>
<td>The $i^{th}$ program list</td>
</tr>
<tr>
<td>$C_{ALL}$</td>
<td>Total Resources consumption of media in all program lists sent by GC</td>
</tr>
<tr>
<td>$N_S$</td>
<td>Total number of program list sent by GC</td>
</tr>
<tr>
<td>$K_S$</td>
<td>Key program list</td>
</tr>
</tbody>
</table>
5. else
6. foreach $S_i$ in $S$
7. if $C_{ALL} - C_S$ less than $Q_{STB}$
8. add $S_i$ into $K$
9. else
10. continue
11. key = Min ($K$)
12. return $K_i$

Figure 4. Key Program Algorithm

Distribute(object $K_i$)
1. define object subk //store sub-node of $K_i$.
2. subk = decompose($K_i$)
3. foreach element subki in subk
4. if playtime of subki is reached
5. send media sources of subki to STB
6. else
7. continue

Figure 5. Time-sharing Distribute Algorithm.

The object $K$ in Fig. 4 is an array, which stores the candidate key program lists. Fig. 5 depicts the distribution algorithm of key program list. The TSDE waits until play time of key reached and then delivers the data to STB.

V. TEST RESULT

To test the effect of TSDE, we deploy the system including IC, SD, GC and TSDE in the campus LAN environment. We run emulation program on 13 hosts in three different network segments. The environment is the same as deployment in real life. And the emulator result is show in Fig. 6 and Fig. 7. CPU and memory usage of STB during long time is showed in Fig. 6. At time t, mess of program list is generated and waited to be sent to STB. CPU and memory usage before time t are nearly same between using TSDE and the situation without it.

But, after t CPU and memory usage is dramatically increased and CPU is up to nearly 100% of STB. It may lead to STB corrupted. However, with TSDE, CPU usage is reduced to 60%, a level that CPU is still running fast. So the performance of whole system still can be ensured.

CPU and memory of STB is relevant to the number of program lists. With count of program lists increase, resources consumption increase too. When program lists reach 110, the consumption goes high rapidly. CPU usage is nearly 90% at the point of 190. By then, response rate of STB has been slowed down. But if TSDE is used before GC distributing media file to STB, the usage of CPU is decreased by 40%. The reason that CPU usage is still 60% through using TSDE is because algorithm in TSDE will first guarantee resources consumption not to exceed STB’s capacity and then try its best to enhance the system’s performance. So the algorithm for finding key program selects the minim one from candidate program list $K$.

VI. CONCLUSION

Nowadays, media system with increasing amount of information is urged required by user. System presented former depends on higher bandwidth and requires promotion in function and performance. In this paper, we have presented a multimedia information publication system based on STB which is more stable and more robust. The system we proposed adopts distributed B/S architecture and reasonably divided into five modules according its characters, which dramatically enhances system’s functionality and usability. Time-sharing distribute engine is used to lower demand of network and avoids resources consumption exceeding STB’s capacity of memory and CPU. And with TSDE, performance of the whole system is improved significantly from the result test.

At the same time, the system currently supports multiple kinds of terminal such as PC, set-top box based on BROADCOM and SIGMA platform. Recently the system has been successfully used in GPRS wireless
network. I believe that the information distribution system will have prosperous future in two directions: one is wireless intelligent system used in 3G network, the other is deploying media system in mobile terminals. In future work, we will pay more attention to intelligent system on mobile phone. How to guarantee the system performance with limited network bandwidth is a curial problem in wireless environment.

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REFERENCES


Xuan Li received her B.S degree in software engineering in 2008 from Fudan University in Shanghai, and she is currently a master student at Software School, Fudan University in China, whose major research fields are streaming media and multimedia network.

LiXin Lin received her B.S degree in software engineering in 2008 from Xiamen University in Fujian, and He is currently a master student at Software School, Fudan University, China, whose major research fields are streaming media, VOD.

Xin Liu received her Ph.D. in Automobile Electronics of Tsinghua University of China in 1999.
She worked as an instructor in Multimedia and network library in Software School of Fudan University.
Dr. Liu has published one paper in SCI level and more than 5 papers in EI level in aspect of network and multimedia system etc.

Dejian Ye received his B.S. degree in Electrical Engineering in 1997 of Zhejiang University, his Master degree in Automobile Electronics of Harbin Institute of Technology in 1999, and his Ph.D. in multimedia and network of Tsinghua University of China in 1999.
He worked as a doctor intern at Microsoft Research Asia from Oct., 2000 to May, 2002, and a visiting professor at Carnegie-Mellon University, America from 2007 to 2008. He is currently an Associate Professor at the Department of multimedia and network, School of Computer Science, Fudan University, in China. He is also the technical director of Clear Crane Tech. LTD. Co.
Dr. Ye has published more than 3 papers in SCI level in aspect of QoS in network and multimedia system etc. Dr. Ye became a member of IEEE in 2003, a senior member of IEICE.
Weihui Dai received his B.S. degree in Automation Engineering in 1987, his Master degree in Automobile Electronics in 1992, and his Ph.D. in Biomedical Engineering in 1996, all from Zhejiang University, China. He worked as a post-doctor at School of Management, Fudan University from 1997 to 1999, a visiting scholar at Sloan School of Management, M.I.T from 2000 to 2001, and a visiting professor at Chonnam National University, Korea from 2001 to 2002. He is currently an Associate Professor at the Department of Information Management and Information Systems, School of Management, Fudan University, China.

Dr. Dai has published more than 120 papers in Software Engineering, Information Management and Information Systems, Complex Adaptive System and Socioeconomic Ecology, Digital Arts and Creative Industry, etc. Dr. Dai became a member of IEEE in 2003, a senior member of China Computer Society in 2004, and a senior member of China Society of Technology Economics in 2004.