

A Lightweight Personalized Image Preloading Method for IPTV System

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Abstract— Owing to the increasing demands on high-quality video, there are numerous services about Video on Demand (VOD) on IPTV platform. Comparing with traditional IPTV channel service, the VOD service often suffers from long loading time because of the page switching and the longest waiting time is the image downloading process. In this paper, we present a lightweight personalized image preloading method for IPTV system which is suitable for embedded devices. According to our experiment result, the training time is less than 0.5 seconds when the training sets are about 1800 and the average time saving on page switching is 1.09 seconds when the prediction accuracy is approximately 30%.

Keywords— IPTV, Preloading, Personalized, Image

I. INTRODUCTION

Due to the fast development of high-quality video and internet infrastructure [1], television is changing from traditional Internet Protocol Television (IPTV) service to over-the-top (OTT) service. IPTV is a channel service that transfers the channel signal through the network cable. It provides user live-channel content, high-quality movie, and other application service [2, 3]. But it usually deploys on an intranet environment which is provided by the Internet Service Provider (ISP). Comparing with IPTV platform, OTT focuses on providing a huge number video contents which are not limited to the single content provider or ISP. Since the OTT platform is not limited to an ISP intranet, it could access all content on the internet.

With the rapid development of the IPTV and OTT service the service provider offering numerous types of application on the IPTV or OTT platform. As applications and services increase, the number of pages or contents in platform increase. In common IPTV architecture, page data preloads on initializing stage. This would cause the exponential growing of the preloading time. Unlike IPTV, OTT does not have the preloading process. When the user switches to the next page, it will start to download the page data including the image, banner, and description. This could prevent the preloading time in large number pages on OTT platform. But users have to wait until the page loading is complete.

In this paper, we propose a personalize image preloading method on IPTV System, capable of taking advantage of personal page browsing behavior, reduce the loading time on initializing stage, decrease the user loading time when switching page and increase the user experience on IPTV Service.

The remainder of this paper is organized as follows. Section 2 explores related works about preloading method on IPTV or OTT platform. Section 3 presents the proposed system, personal preloading method on IPTV platform, and a detailed description of each module. Section 4 provides experiment data about the design system. Finally, Section 5 presents the concluding remarks.

II. RELATED WORK

In the common IPTV architecture, caching is an important technique which could prevent the recent using resource download repeatedly. This could reduce the waiting time when accessing the same page. However, the longest waiting time is opening the page that has never loaded. In this paper, we present a lightweight personalized preloading image approach on IPTV system. There are numerous researches about preloading on IPTV or OTT system.

There is a research about preloading on IPTV channel [4]. In this research, the authors present a personalize channel preload technique on IPTV system. This paper defines the Hot-view Channel List and Personality-Favorited Channel List [4]. The Hot-view Channel List is provided from the IPTV server and is the Hot-view channel from all IPTV users. The Personality-Favorited Channel List is the user-configured list which could be modified through the user interface on IPTV client. By using those list, the system could predict which channel is most likely to switch to.

The other research is an intelligent preloading approach on the website [5]. This approach using Markov Model for sequence prediction. States in Markov are defined from the website page. When the user is browsing the website, the requesting session is logged and send to the Hadoop server which is a cloud computing technique similar to [6] for user behaviour analysis. The server will return the state transition matrix based on the clustering result of users. Finally, the user could preload the highest probability of next page and reduce the waiting time on loading the next page.

In other paper, the preloading technique based on user's interest is used on a mobile device [7]. Because of the unstable connection on mobile, the authors propose a caching method based on user's interest. After calculating the interest value, the method finds the association post on the social network and preload it.

III. SYSTEM DESIGN AND METHOD

In this paper, we propose a lightweight personalized image preloading IPTV system and Figure 1 is the system architecture. IPTV server contains all channel and video contents. In our proposal, the IPTV server stores additional data including category information and extended image metadata. Compare with traditional IPTV system, the proposed IPTV client only download category tree and home page data in the initializing stage.

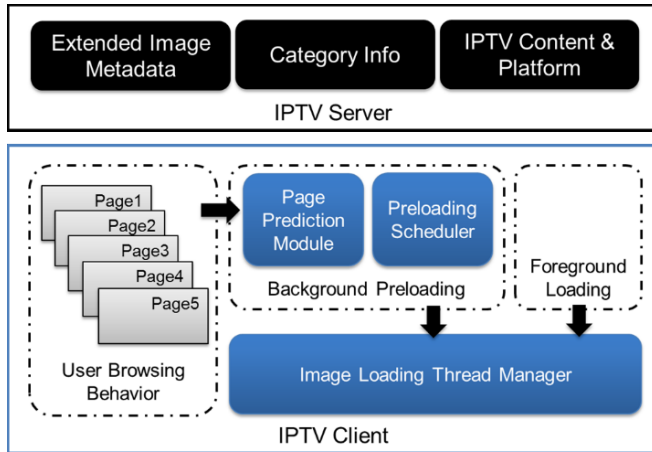


Figure 1. System architecture

Category information is stored in a tree structure as shown in Figure 2. The root of this tree is the home page and the first level of the tree branch is the category that could be clicked from the home page. When client connecting to the server, it will download the category tree and store in local memory. Each element in the tree structure is a key-value data which represent an identification to a category name. An identification is corresponding to one page. This identification could be used later by the extended image metadata.

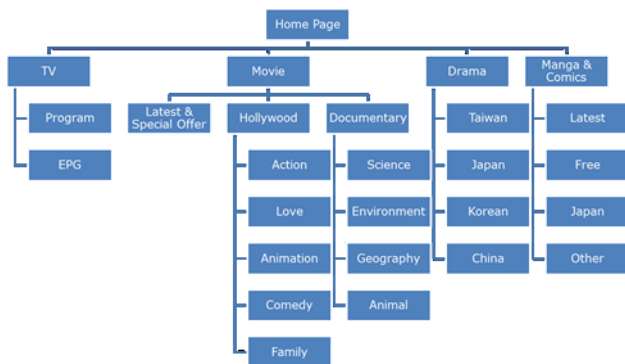


Figure 2. Category tree

The image metadata is the common data storing on IPTV server. In this paper, we propose an extended image metadata that could be associated the image with the category identification, advertisement, and recommendation as shown in Figure 3. The category identification could be corresponding to

multiple pages. This implies that the image could be shown at multiple pages. Advertisement and recommendation attribute could help the IPTV client extend cache storing the time of the image and increase the priority of download thread.



Figure 3. Example of Extended Image Metadata

IPTV client is the main user interface in IPTV system. Normally it will provide its user interface with a set-top box (STB). In this paper, the client also contains Page Prediction Module, Preloading Scheduler, and Image Loading Thread Manager.

Page Prediction Module is a sequence prediction module using Compact Prediction Tree (CPT) [8]. In the training stage, the module collects the user page switching data and construct the Prediction Tree (PT), Inverted Index (II) and Lookup Table (LT). The CPT training stage is extremely light in weight and suitable for STB device because computing power on STB is much lower than other embedded devices. The prediction phase calculates Sequences Similar and Count Table. The Sequences Similar process is done by the intersection of II and the given sequence. The Count Table is calculated from LT, PT, and Similar Sequences. After finding the Count Table, the prediction phase is complete and the next probability of page x is defined as shown in equation X below. N is the number of pages.

$$P_{xNext} = \{P_1, P_2, P_3, \dots, P_N\} \quad (1)$$

When Page Prediction Module is complete the prediction process, Preloading Scheduler takes three highest next page probability and calculates the number of page k loading task as shown in equation 2. Total Cache Size is the STB image caching allocation size which is usually one-third of the free memory and Average Image Size is the average size of all image content on IPTV server. The estimated number of total image that could be loaded into the cache is calculated by division of total size by average size. We use one-third of estimated number of the total image in order to minimize the occupation of preloading image size in the total cache.

$$N_{Imagek} = \frac{1}{3} \times \frac{\text{Total Cache Size}}{\text{Average Image Size}} \times \frac{Pk}{\sum_{n=1}^3 P_n}, k \in 1, 2, 3 \quad (2)$$

In this paper, we present a lightweight scheduler algorithm for embedded devices as shown in Figure 4. The main target of this algorithm is to schedule the preloading request by the proportion of each prediction candidate.

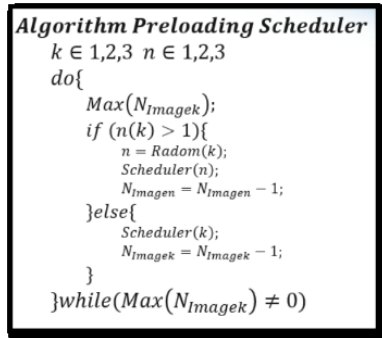


Figure 4. Preloading scheduler algorithm

Image Loading Thread Manager is the thread manager of preloading and foreground image loading. Foreground image loading is the download request when user browsing page. Each request from the foreground page has the higher priority than the background page. When one of the thread workers in manager is idle, it will accept the request from the background page, preloading page, and start to download the image. The number of background thread is defined as shown in equation 3. N_{worker} is the number of thread workers which is usually the number of cores in Central Processing Unit(CPU). T_{fore} represents the number of foreground task waiting in the thread queue and T_{back} is the background task.

$$N_{back} = \begin{cases} 0, & T_{fore} \geq N_{worker} \\ N_{worker} - T_{fore}, & T_{fore} < N_{worker} \end{cases} \quad (3)$$

IV. EXPERIMENT AND RESULT

The experiment environment is the Chunghwa Telecom MOD platform. In this platform, Chunghwa Telecom provides numerous application services including live channel, movie, drama, sports, news, weather, etc. The hardware is a STB with a quad-core 1.5Ghz ARM Cortex-A5 CPU running Android 4.4 system. We develop the client method on STB and MOD platform. We choose 100 random customers and use Over-The-Air (OTA) updating the STB software.

In our proposed method, the client side system is light weight and is suitable for STB as shown in Figure X. Due to the multithread implementation, the Page Prediction Module could finish the training stage in about 0.3 seconds with 1000 sequence sets.

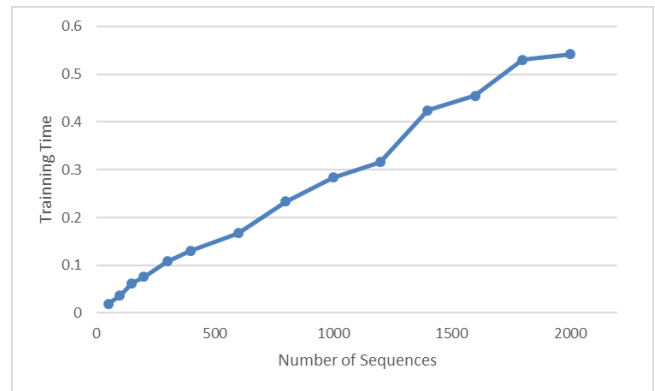


Figure 5. Training time with number of sequences

The prediction accuracy and number of training sequences is shown in Figure X. The prediction accuracy is approximately 40% when the number training sequences are 1600. In most prediction error case is the user press the home button and return to the main page or user return to the last page. In those cases, users do not suffer from waiting time because the pages have loaded and stored in the disk cache. But the prediction error will cause the bandwidth and cache wasting. The graph also shows that the prediction accuracy increases rapidly from about 600 to 900 training sequence sets.

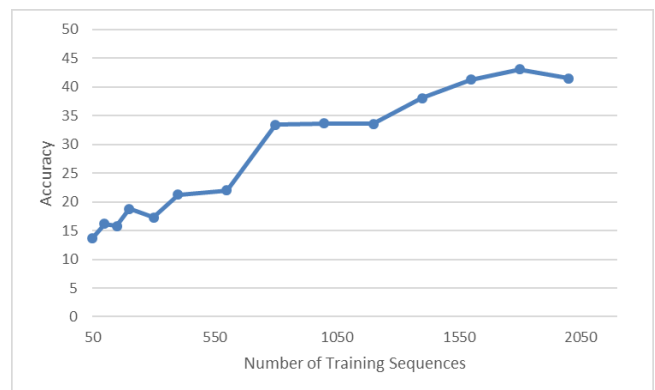


Figure 6. Accuracy with number of training sequences

In our 100 customer tests, we calculate all prediction accuracy and average time saving on loading next page as shown in Table 1. When prediction accuracy reaches about 40% the average saving time is 2.15 seconds.

TABLE 1. AVERAGE SAVING TIME ON EACH ACCURACY

Prediction Accuracy	Average Saving Time
10%	0.32 Seconds
30%	1.09 Seconds
40%	2.15 Seconds

V. CONCLUSION

In this research, we present a personalized preloading method on IPTV system. It could preload the prediction page when the network and system are in idle state. In Section 4, the experiment result shows that the training stage is fast and suitable for the STB. In the future work, the learning process could add the category tree from IPTV server. This could improve the prediction accuracy when the training sets is insufficient.

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