Implementation of TV-Anytime Compliant STB for Personalized TV Services

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Abstract - In this paper, we present a design and implementation of a TV-Anytime compliant STB to provide personalized content consumption according to user preferences and various terminal/network conditions. This paper mainly details with a metadata engine which consists of metadata de-multiplexing, metadata decoding, and metadata-based content browsing. For personalized content consumption, the proposed metadata engine provides the following key functionalities: advanced EPG, non-linear segment navigation wirh Tables-of-Content and/or event-based summary, automatic recommendation of user-preferred programs, and etc. The implemented STB employing the metadata engine is successfully tested with a set of service scenarios in an end-to-end broadcasting test-bed.

Index Terms - TV-Anytime, Metadata, Personalized, Content Browsing, Personal Digital Recoder

1. INTRODUCTION

As digital broadcasting is evolving to more complex and diverse environment due to rapid increase of channels and content as well as various user devices and networks, the personalized TV service becomes increasingly important. The TV-Anytime Forum specifies a set of metadata to be used for efficient access and browsing of broadcasting content in a personalized way [1], [2].

There are a few literatures for personalized TV service such as [3]-[7]. These works just concentrate on the recommendation and representation of TV programs depending on the user profile. Therefore, it is not enough to develop a consumer electronic, set-top box (STB) with high volume storage (often called as personal digital recorder (PDR)).

In this reason, we present an overall system architecture of the STB in a view of metadata engine and then propose several technologies for content consumption based on the TV-Anytime metadata with the following key functionalities: advnaced electronic content guide (ACG), non-linear segment navigation with table-of-content (ToC) and/or event-based summary, keyword-based segment search, automatic program recommendation according user preferences, and etc. Considering home network environment, we also propose a metadata-based adaptive content access and consumption using a mobile PDR such as PDA.

The proposed metadata engine is integrated into a Linux-based STB, and it is successfully tested with a set of personalized service scenarios in an end-to-end broadcasting test-bed.

2. PROTOTYPE SYSTEM OF DIGITAL SET-TOP BOX

The architecture of a prototype system of STB is shown in Fig. 1. It consists of a main-PDR with an ATSC tuner and a sub-PDR (PDA). The main-PDR consists of the following components:

- Metadata De-multiplexer: MPEG-2 TS De-multiplexing, De-capsulation
- Metadata Decoder: BiM (Binary format for MPEG-7)/TeM (Text format for MPEG-7) Decoding
- Metadata Consumption
  - Metadata Processor: functions for personalized content consumption
  - Metadata/Media Storage
  - Media Presentation: Segment Presentation, Random access

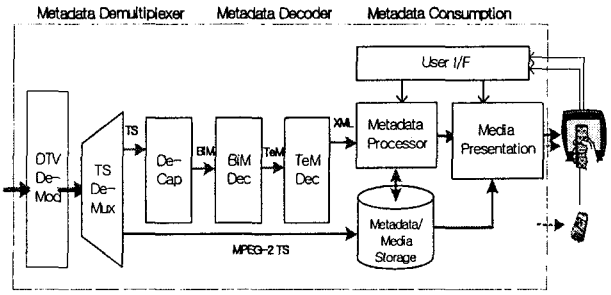


Fig. 1. Overall architecture of the set-top box.

3. METADATA DE-MULTIPLEXING AND DECODING

The implemented STB receives the delivered MPEG-2 TS multiplexing AV contents and metadata with a sequence of demodulation, demultiplexing, and decapsulation in real time. The metadata of BiM format are decoded into an XML form and manipulated (i.e., parsed, populated into a DB, etc.) for allowing personalized content consumption.

3.1 Metadata De-Multiplexing

The process of de-multiplexing is illustrated in Fig. 2. By analyzing PMT (Program Map Table) at first, the value of PID (packet identifier) [8] assigned to metadata and AV

contents can be identified. By referring "stream type" included in the PMT, we can know which protocol was used for transporting metadata. By parsing the delivered transport stream according to the used protocol, we can extract the pure metadata, which will then be passed to the metadata decoder (here BiM decoder). As well, AV contents will be passed to a MPEG-2 decoder.

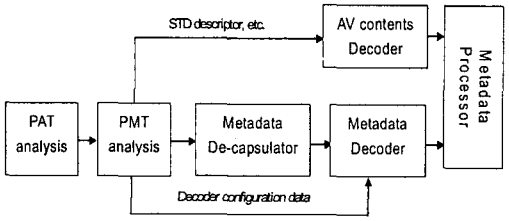


Fig. 2. The process of de-multiplexing.

3.2 Metadata Decoding

As illustrated in Fig. 3, the BiM decoder receives DI and metadata stream and reconstructs delivered metadata. First, a FUU decoder is initialized by initial parameters and schemas come from the DI. After initialization by the initial description, a description tree is updated by subsequent AUs from the description stream [9]. Then, each FUU component is extracted from a given AU in a FUU decoder.

A FU command decoder refers to a simple look-up table to decode the update command and passes it to a description composer. Decoded FU context information is passed both to the description composer and to a FU Payload decoder. Aided by the FU context information, the FU Payload decoder decodes a FU payload to yield a description fragment. The FU Payload is composed of a flag defining a certain decoding modes and a payload content which can be either an element or a simple value. In particular, a complex type with complex content is decoded by a finite state automation decoder (FSAD). After an entire metadata description is recomposed and saved in the metadata/media storage, personalized content browsing services using metadata can be provided in the metadata processor.

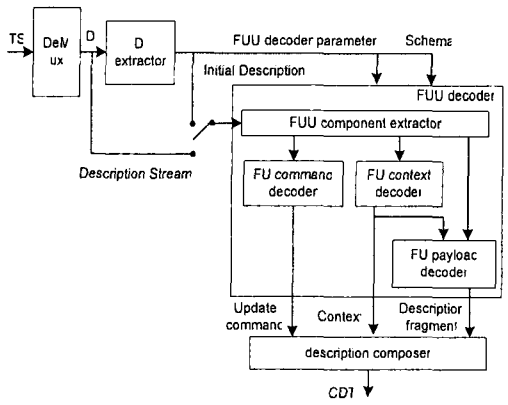


Fig. 3. BiM decoder architecture.

4. PERSONALIED CONTENT CONSUMPTION

Various kinds of personalized content browsing services based on metadata are provided in the metadata processor as follows:

4.1. Metadata-based intelligent/customized content access and consumption

- ACG (Advanced electronic Contents Guide)

ACG is one of the most important functions when a large number of channels are available. Fig. 4(a) shows the ACG. It shows a weekly time table in which the programs from the same time slot are listed in the order of user's genre preference.

- ToC (Table of Contents) Browser

From the ToC, users can perceive the overall story structure of the content and have access to the content in segment units. Users can select and watch a specific segment after browsing the hierarchical structure of the content.

- EbS (Event-based Summary) Browser

Event-based summary in Fig. 4(b) provides the function similar to the index found at the end of a book. Informative genre such as news and documentary is suited for browsing with the event-based summary. For testing, we selected a news program in which each segment is classified into political, international, social, and economic item according to the subject.

- Keyword-based search on segments

Fig. 4(c) shows the keyword-based search on programs and segments. User can retrieve interesting programs and/or segments using keyword which is a word of title, synopsis, actor list, and etc.

4.2 Personalized consumption based on user preference

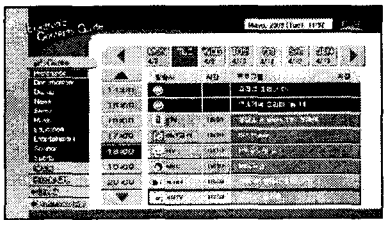
- Personal Channel

Personal channel is program rescheduling service according to various kinds of user preferences or life styles that happens dynamically in the STB after the ACG information has been collected from a number of service providers

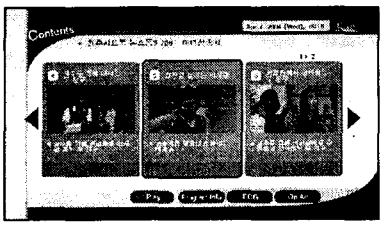
4.3 Customized contents service on Sub-PDRs in Home -network

- Remote control of main-PDR by sub-PDR & Personal Program

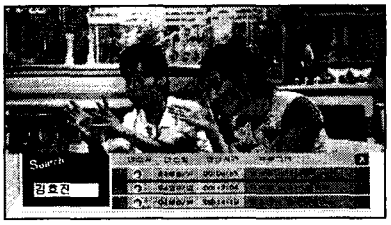
In the home network environment that various kinds of devices (e.g. PDA, MP3 player, DVD player, etc.) are connected by networks, users may still want to access the multimedia information without effort anytime and anywhere. To achieve the above requirement, we developed a notion of a personal program, which is programming service customized to user preference and consuming environment, as shown in Fig. 4(d). In addition, we integrated remote control function on a sub-PDR.



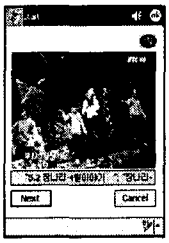
(a) Advanced electronic Contents Guide



(b) Event-based Summary



(c) Program/Segment Search



(d) Personal Program on PDA

Fig. 4. Personalized content browsing services.

5. PERSONAL CHANNEL

Personal channel service is based on program rescheduling according to various kinds of user preferences or life styles that happens dynamically in the PDR after the ECG information has been collected from a number of service providers. The rescheduled programs can be provided via the personal channel at the preferred time.

Fig. 5 shows the inter-operations between a service provider and a PDR for the personal channel service. The service provider offers data for content reference identification, location resolution [10] together with the metadata such as content description metadata and instance description metadata which are specified in the TV-Anytime standard [11].

All the received metadata are stored and managed in the metadata collector (MC) of the PDR. Then, ECG can be rendered via user interface using the collected metadata. The user can browse and select a program from the ECG, and watch the program at the scheduled time. After iterative user actions such as browsing, watching, playing, recording, etc., the usage history is stored in a user profile and subsequently used for extracting user preferences for the date (day and time), genre, program title and so on. The extracted user preference metadata are also stored in the MC and referred to by the personal channel controller to build a virtual channel comprising only the preferred programs that are rescheduled to the desired time. That is the corresponding personal channel.

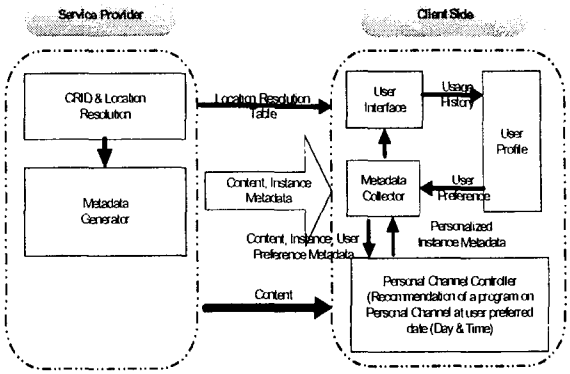


Fig. 5. System interaction for personal channel service.

5.1 Basic Concept for Personal Channel

To rearrange the preferred programs for the personal channel in the personal channel controller is on the basis of the fact that a preferred program is placed for the desired future date (day and time) at the current time when PDR does the rearrangement procedure. Therefore, in terms of time, there are four important concepts as shown in Fig. 6. Those are as follows.

- Re-schedulingTime (current time): The time to do rearrangement procedure
- UserPreferredTime (future time): User's desired time to watch a preferred program
- Saved: Programs already stored in PDR before the Re-schedulingTime
- Will-Be-Saved: Programs to be saved between the Re-schedulingTime and the UserPreferredTime.

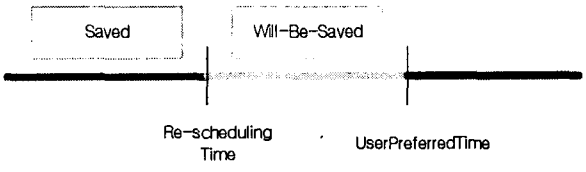


Fig. 6. Important time points and program groups for rearrangement.

And the rearranged program can be stored program in the PDR or real-time streaming according to user preference. The rearrangement algorithm for each case is shown in the Fig. 7 and Fig. 8, respectively.

5.2 Personal Channel Organization Algorithm

By the above algorithms, the tailored personal channel and its new programs are included in the ECG information as shown in the Fig. 9. Then, the personal channel is rendered to the ECG screen of Fig. 2(a) along with the other (actual) channels.

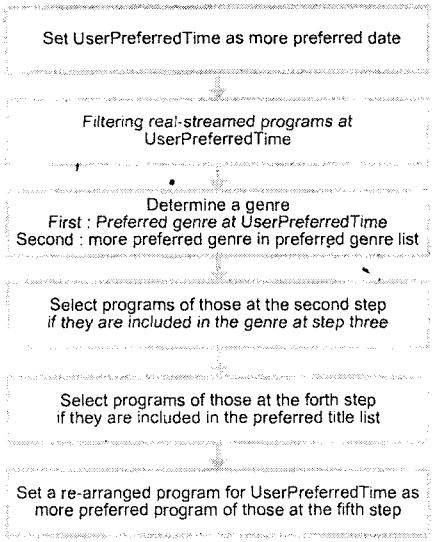


Fig. 7. Rearrangement algorithm for real-time streaming preferred date.

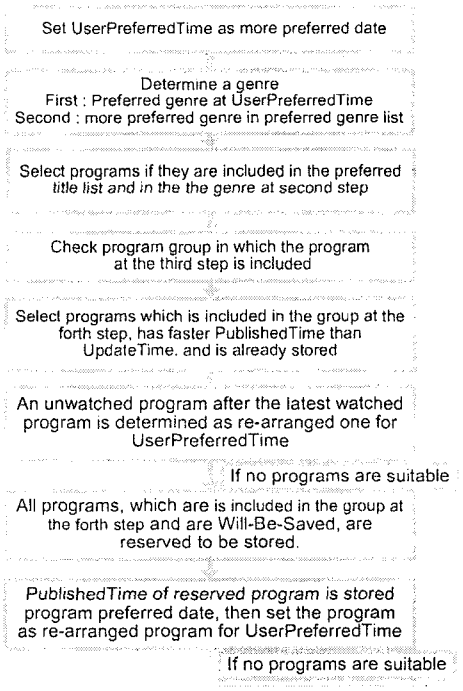


Fig. 8. Rearrangement algorithm for stored program preferred date

6. PERSONAL PROGRAM

In the home network environment that various kinds of devices (e.g. PDA, MP3 player, DVD player, etc.) are connected by networks, as mentioned in Section 2.4, users may still want to access easily to and use efficiently the multimedia information without effort anytime and anywhere. To achieve the above requirement, we developed a notion of a personal program, which is programming service customized to user preference and consuming environment. Fig. 10 shows the proposed system architecture for the personal program service.

```
<ProgramDescription>
 <ProgramLocationTable>
   <BroadcastEvent>
     <Program crid="crid://imbc.com/sangdo/epi
       sode18"/>
     <BroadcastURL> My PDR/personal/
     </BroadcastURL>
     <EventDescription>
       <PublishedTime>2002-04-20T11:00:00.00
       </PublishedTime>
       <PublishedDuration>PT50M
       </PublishedDuration>
     </EventDescription>
     <ServiceId id="Ch2"/>
   </BroadcastEvent>
 </ProgramLocationTable>
 <ServiceInformationTable>
  <ServiceInformation serviceId="Ch2">
    <Name>PERSONAL</Name>
    <Owner>My PDR</Owner>
  </ServiceInformation>
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```

Fig. 9. ECG information with the personal channel and its programs.

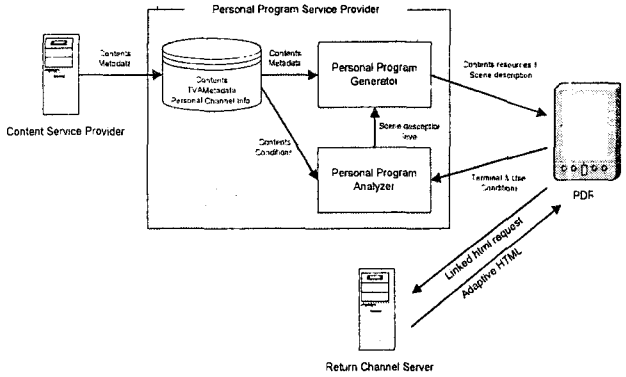

Fig. 10. A system architecture of for personal program.

The system consists of following entities,

- Personal Program Service Provider: to provide personal program for PDRs
- Contents Service Provider: to provide broadcasting content on a certain transmission channel
- Return Channel Server: to provide linked materials with a certain broadcasting content
- Personal Program Player: to decode and render the personal program at PDR

The operation proceeds as follows: Contents service provider provides contents and metadata to the personal program service provider. Then, the personal program analyzer in the personal program service provider receives various conditions from metadata storage and PDR device to decide how an instance of scene description for certain content is generated. Here, the conditions include characteristics of content, user, and terminal, etc.

The system defines several kinds of conditions, and their some examples are as followings:

- Terminal condition: terminal capacity information such as screen size, storage capacity, CPU capability, etc.
- User condition: usage environment for personal program.
- Content condition: content characteristics such as genre, mood, action, etc.

The personal program generator module generates a real

instance of scene description and content resources such as images, audio, text, and HTML. These scene descriptions and content resources are sent to PDA, and a player capable of handling this scene description, called personal program player, renders the personal program. The personal program player also requests a return channel server for the linked material if necessary, and the return channel server provides the requested material. Fig. 11 shows the operation procedure of system for the personal program service.

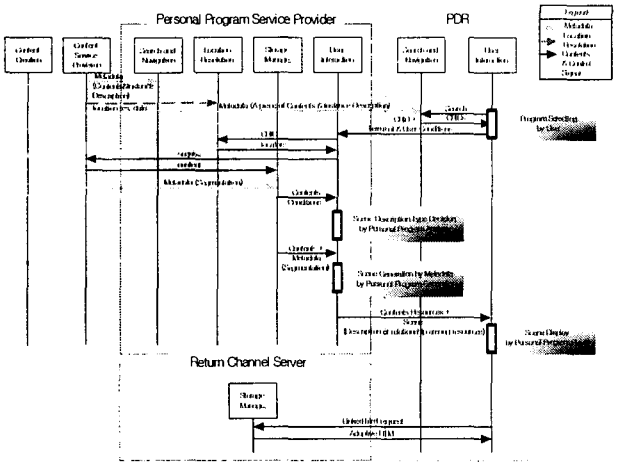

Fig. 11. the operation procedure of system for the personal program service

For scene description, MPEG-4 XMT-O [12]-[14] is used with the following technical points considered: synchronization between resources, human readability, compatibility with other standard scene description technologies such as MPEG-4 BIFS and SMIL.

The personal program player supports functions for parsing and rendering XMT-O instances. Fig. 12 shows key shots of this player. Using the personal channel browser displayed on the PDA, as shown in Fig. 12, a user can select a program customized to his/her personal PDR device. In addition, the user can choose scene description type that is one of scene description types supported by the personal PDR device. Upon selected, the program can be presented in the preferred way as shown in Fig. 2(d).

7. CONCLUSIONS

We present a prototype system of a digital set-top box based on TV-Anytime system model. From the result of implementation and experiments with HD contents (1920x1080i, 19.4Mbps) and metadata (2 weeks/25 ch EPG: 7,500 programs), its functions are proved to be effective to search and browse broadcasted programs. The personalized services, such as personal channel and personal program, are developed. By extracting the instance of metadata description based on TV-Anytime specifications, the proposed services can be served between the TV-Anytime compatible devices. These technologies can be applied to intelligent and customized digital TV broadcasting terminal, web-based customized services using user preferences, and a broadcasting multimedia home server.

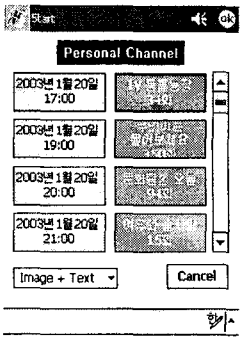

Fig. 12. A personal channel on PDA

ACKNOWLEDGEMENTS

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