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User-Centric Broadcasting Environment Using Intelligent Agents

Sung Ho Jin[†], Tae Meon Bae[††], Jun Ho Cho[†††], Yong Man Ro[††††], Kyeongok Kang[†††††]

ABSTRACT

The user-centric broadcasting environment includes the agent system and personalized broadcasting services for user-adaptive TV watching. In this paper, we propose broadcasting environment consisting of personalized broadcasting services and a multi-agent broadcasting system for the services. The proposed system employs the intelligent agent technology of the Foundation for Intelligent Physical Agents (FIPA) as well as metadata technology of MPEG-7 and TV-Anytime Forum (TVAF). To verify the usefulness of the proposed environment, we implemented a test-bed and demonstrated the proposed agent system with three services including intelligent user-information management service, information mobility service, and content retrieval service.

Keywords: User-centric broadcasting, Intelligent agent, MPEG-7, TV-Anytime Forum, FIPA

1. INTRODUCTION

Since digital TV broadcasting was introduced, broadcasters have been developing the interactive broadcasting services. As it is possible to support interactivity between broadcasters and TV viewers, the importance of user-centric broadcasting services has emerged and has been increasing. However, current broadcasting technologies have been supporting limited services such as reservation recording, program guiding with the electronic program guide (EPG) on personal video recorder systems[1], and primitive data broadcasting by broadcasters[2].

In order to meet the needs of user-oriented services in digital broadcasting, it is suggested that broadcasting systems should analyze TV viewers' intentions with their profiles and preferences and provide corresponding contents or information. Therefore, users' terminals could offer adaptive and interactive TV watching environments to them in response to their requests or tastes.

For intellectual functions of broadcasting system, it is suitable to adopt software agent technology, which can help interactions between system terminals and give intelligence to them. The software agent, which originated from the artificial intelligence field several decades ago, replaces a user to

※ Corresponding Author : Yong Man Ro, Address : (305-732) 119, Munjiro, Yuseong-gu, Daejeon, Korea, TEL: +82-42-866-6289, FAX : +82-42-866-6245, E-mail : yro@icu.ac.kr

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[†] School of Engineering, Information and Communications University.
(E-mail : wh966@icu.ac.kr)

[††] School of Engineering, Information and Communications University.
(E-mail : heartles@icu.ac.kr)

[†††] School of Engineering, Information and Communications University.
(E-mail : chojunho@icu.ac.kr)

[††††] School of Engineering, Information and Communications University.
(E-mail : yro@icu.ac.kr)

[†††††] 3D Media Research Team, Electronics and Telecommunications Research Institute
(E-mail : kokang@etri.re.kr)

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act a work and automatically solves the one's problem[3]. A few previous approaches have tried to employ agent technology to broadcasting systems and service scenarios[4-6].

Recently, a new digital broadcasting environment, the Super-intelligent Multimedia Anytime-anywhere Realistic TV (SmarTV) project, is in progress as a national Korean project for the next generation of television. The goal of the project is that end users are able to use customized broadcasting programs as well as multimedia information services according to their preferences and needs through advanced broadcasting networks or integrated networks of broadcasting and communication[7].

In this paper, a user-centric broadcasting system is designed by using multi agents as the partial works for the SmarTV. The proposed system offers the user-centric broadcasting services. First, it provides intelligent management of users' information by agent such as generation and update of user preferences and user preference based content recommendations. Secondly, TV viewers can retrieve personalized contents through agents' network channels, which give efficient and harmonic interaction between system terminals. Thirdly, we have considered user-information mobility or watching situation mobility service in which the viewers could use their preferences or profiles, when they move from their home terminal to a foreign terminal.

The methodologies used to achieve the above goals of this paper are as follows: We apply FIPA agent technology to add self-controlling functions and intelligence to the broadcasting terminals and adopt the TVAF standard for transmitting metadata. Also, we use content and metadata authoring techniques using MPEG-7 multimodal as well as multiple features so as to provide contents and metadata efficient and effective corresponding to users' requests. To demonstrate the usefulness of the proposed agent system and services, we implemented a test-bed framework and performed experiments for personalized broadcasting services including intelligent user-information management service with broadcasting based on user-preferences, information mobility service, and contents based retrieval service based on users' queries.

2. USER-CENTRIC BROADCASTING AGENT SYSTEM

In a general interactive broadcasting system, a TV viewer needs interactive operations to exchange information and search contents with one's own terminal and content service providers. For example, after deciding on a specific content, the viewer should find the location of the selected content from a content service provider. Additionally, the one needs to perform inter-communication between them. To minimize these kinds of viewer's efforts and replace their operations, it is evitable that the system should have intelligence. Therefore, agent, which has the characteristics of autonomy, intelligence, and co-operability, is suitable to achieve the above objective.

For the user-centric broadcasting environment, we developed the proposed broadcasting agents system on top of FIPA-OS, one of FIPA agent platforms. The proposed agent system could provide a user-friendly watching environment by minimizing users' operations and providing intellectual functions. It is composed of three independent agent platforms: The first agent platform, called User-Terminal, directly interacts with TV viewers. The second agent platform, Service Provider, responds to a viewer's query and provides metadata or contents to User-Terminals. The third agent platform is Service Information Provider which is an intermediary between User-Terminals and Service Providers. The architecture of this system is shown in Fig. 1.

The FIPA agent platform supports protocols for communication between heterogeneous agents[6]. Therefore, it easily materializes internal or ex-

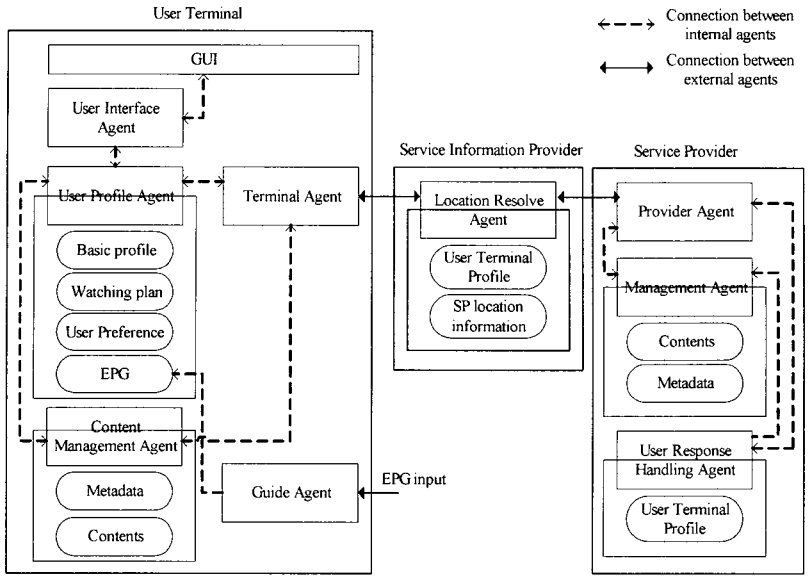


Fig. 1. Architecture of the proposed agent system for the user-centric broadcasting services.

ternal-communication between agents through the Agent Communication Channel (ACC). When one platform starts to run, all agents of the platform are registered at the Directory Facilitator (DF), which is a mandatory component of an FIPA agent platform to provide a yellow pages directory service to agents. Hence, each agent can communicate internally via the DF in one platform. Additionally, by accessing the DF in an external platform, one agent can communicate with others which are registered in the external platform. It is important to exchange metadata as well as a user's intention through a return channel for user-centric services. Without assigning a new return channel, the proposed agent system adopts the FIPA agent communication channel between agent platforms.

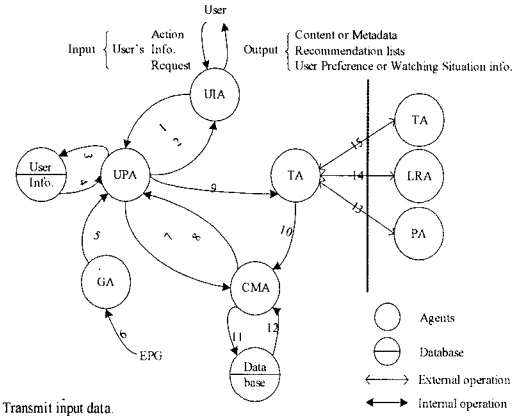
The following sections are detailed explanations about the proposed agent platforms.

2.1 User-Terminal Agent Platform

The User-Terminal agent platform deals with viewer's input or output. A viewer can input information and intention and consume a desired content and metadata in this platform. It has three functions: The first function is reservation recording, which automatically stores contents and programs according to a watching plan preset by users. For this function, the agents of this platform operate autonomously regardless of a user's log-on or log-off. As the second function, the terminal selects and stores contents or programs based on user-preference (*i.e.*, user's watching behaviors). Furthermore, it can recommend the content list of locally saved contents or EPG to users. The schema of the user-preference used in the system originates from the TVAF standard (see Section 4.1). Finally, the User-Terminal provides a content retrieval function so that a viewer can obtain favorite contents from one's own terminal or external content service providers.

The layout of User-Terminal and connection with agents are shown in the left box of Fig. 1. This platform has five agents: User-Interface Agent (UIA), User-Profile Agent (UPA), Content Management Agent (CMA), Terminal Agent (TA), and Guide Agent (GA). The main operations of the agents are shown in Fig. 2, and their roles are as follows:

UIA is the agent that directly interfaces with TV viewers. It transfers the input information to other



(1) Transmit input data.
(2) Recommend content lists; Display original EPG and Content or Metadata; Receive Watching Situation Info.
(3) Generate or Update user information.
(4) Fetch user information.
(5) Update EPG.
(6) Receive EPG.
(7) Transmit user preference.
(8) Receive content or metadata.
(9) Send User's request.
(10) Input content or metadata.
(11) Filter and Save content or metadata.
(12) Fetch content or metadata.
(13) Negotiate with TA of external User Terminal.
(14) Negotiate with LRA of Service Information Provider.
(15) Negotiate with PA of Service Provider.

Fig. 2. Agents' main operations in a User Terminal platform.

agents and controls GUI processing with UPA.

UPA generates and updates a user's information, and it provides the information and EPG to UIA as well. The user's information consists of a basic profile, a watching plan, and a user-preference. For content filtering, the agent transmits them to CMA.

TA communicates with agents of external platforms. It plays the role of a broker between agents of the User-Terminal and the other platforms. For example, when a viewer requests a specific content or metadata from Service Providers, the TA contacts Service Information Provider to get the location information of the Service Providers and then negotiates with the Service Providers about the user's request.

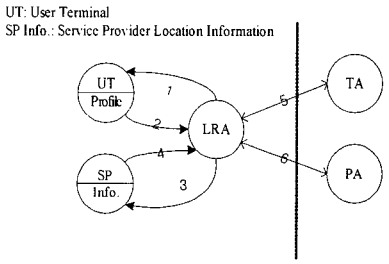
CMA filters contents coming from the Service Providers according to a watching plan or user-preference and stores the filtered data in a local database. When UPA demands contents or metadata for content recommendation, it supplies them from the database.

GA deals with EPG information transferred from the Service Providers. The agent transmits it to UPA for updating or making a recommendation list of live programs.

2.2 Service Information Provider Agent Platform

As shown in Fig. 1, the Service Information Provider agent platform has a structure that includes two databases and one agent. One of the databases is for the User-Terminal's profile, and the other is for the location information of Service Providers. The terminal profile includes the location information, a user's ID, password, and the User-Terminal's name. It is required when user-information mobility or watching situation mobility service is performed. When a user-sends a query to the Service Provider, the User-Terminal needs the information to recognize the Service Provider's location. The Location Resolve Agent (LRA)'s main operations in this platform are illustrated in Fig. 3, and its role is represented as follows:

LRA manages the databases and plays the broker role between the agents of the User-Terminal and the Service Provider. Also, it does internal processing to generate and update the databases.



(1) Request or Update User Terminal profiles.
(2) Fetch User Terminal profiles.
(3) Request or Update Service Provider location information.
(4) Fetch Service Provider location information.
(5) Negotiate with TA of User Terminal.
(6) Negotiate with PA of Service Provider.

Fig. 3. Agent' main operations in a Service Information Provider platform.

2.3 Service Provider Agent Platform

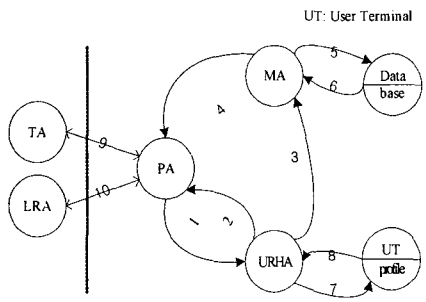
In the proposed agent system, the role of the Service Providers agent platform is to provide contents or metadata in response to users' re-

quests. This platform has two functions: One is to analyze a user's query and offer contents and metadata matched with the query. The other is to recommend contents or metadata autonomously using a statistical analysis about a user's behaviors.

The right box of Fig. 1 shows the agent platform that has three agents. The agents are Provider Agent (PA), Management Agent (MA), and User-Response Handling Agent (URHA). Fig. 4 shows the main agents' operations in the Service Provider and the following describes their roles:

PA communicates with the agents of external platforms such as TA and LRA. Therefore, we can see that the role of PA is similar to those agents.

MA is similar to CMA in the User-Terminal. It controls storing and updating contents and metadata made by a content authoring tool. In order to generate metadata and video skims, this agent needs the content authoring tool.



(1) Receive Query from User Terminal.
(2) Send Content or Metadata.
(3) Send analyzed user's request.
(4) Receive Content or Metadata.
(5) Request Content or Metadata.
(6) Fetch Content or Metadata.
(7) Generate or Update User Terminal profiles.
(8) Fetch User Terminal profiles.
(9) Negotiate with TA of User Terminal.
(10) Negotiate with LRA of Service Information Provider.

Fig. 4. Agents' main operations in a Service Provider platform.

URHA resolves a user's request. If the Service Provider receives a user's query from the User-Terminal, the agent analyzes and processes it. In analyzing the query, this agent gathers user's watching behaviors, profiles, and consuming statistics. After that, it resolves what kinds of contents users want to watch and Service Provider can recommend the resolved contents to users. This process is performed with a user's characteristics and an appropriate timeline from the statistical results about user's behaviors.

3. USER-CENTRIC BROADCASTING SERVICES

The proposed agent system offers three user-based broadcasting services such as intelligent user-information management service, information mobility service, and content retrieval service.

First, the intelligent user-information management service utilizes the autonomy of users' terminals. By using user's usage history and profile, the agents, UIA and UPA, generate, store, and update the user's information, which consists of a basic profile, a user-preference, and a watching plan: 1) The basic profile includes basic information such as user's name, age, gender, and tastes. 2) The watching plan is the schedule for the reservation recording with channel and time information. 3) The user-preference is adaptive information determined by watching behaviors and user's actions. Then the agents can recommend contents or metadata to the viewers on the basis of their information. For example, a user logs on User-Terminal and UIA changes the watching environment into the user-customized one by using one's own information. As soon as one logs on, the agent selects and shows a live program of a channel chosen by one's preference in that time slot (*i.e.*, morning, afternoon, and evening). Also, the agent retrieves and recommends contents from locally saved contents or from EPG, which represents live programs. One can also select and watch one's desired program from the content list. At the same time, the usage history about these actions updates the preference. Additionally, the User-Terminal allows one to choose not only a full version but also a summary version of a program

(*i.e.*, a video skim) within the saved contents.

Secondly, the information mobility service allows TV viewers to use their information anytime and anywhere. It means that the service supports a user's information and watching situation information at a foreign terminal as well as at a home terminal. Also, when one stops watching a broadcasting content at a specific scene and moves to another terminal, the UIA of the home terminal records the watching situation information at that time. Then one can get the same watching situation information and watch the content from the scene after the move. For this service, a user should obtain the location information about the home terminal from an intermediate system, a Service Information Provider, and then one gets one's preference or watching situation information from one's home terminal after authentication.

Finally, the content retrieval service is a user's request based service. TV viewers can retrieve their desired contents through agents' network channel with efficient and harmonic terminal interaction. When a viewer desires to watch a favorite program, UIA searches a local database for it. If there are not corresponding contents in the local database, the agent broadcasts the query to Service Providers automatically. Then the providers parse and analyze the query. After that, they look for contents matching the query and respond to it.

This retrieval service includes keyword, semantic video scene, and original sound track (OST) retrieval. The keyword retrieval is a searching function using text-keywords such as genre, actor, or title. The semantic video scene retrieval is performed by selecting a key-image or recognizing a user's speech. For this to happen, it is essential to detect semantic scenes from broadcasting contents and record the information about them at the Service Provider. The OST retrieval offers the music chosen from the broadcasting content with CD quality, and its additional information such as title, singer, or composer. In order to support the above broadcasting services, content authoring techniques are necessary in the agent system. Multimodal as well as multiple features of the MPEG-7 audio/visual descriptors could be used for the techniques [14,15].

4. SYSTEM COMPONENTS FOR THE USER-CENTRIC BROADCASTING SERVICES

For the user-centric broadcasting services, the proposed agent system has three key components: user-preference, metadata, and content authoring. This section shows how to generate the user-preference and metadata and presents how to exchange the metadata within the agent platforms. Furthermore, content authoring is described.

4.1 User-Preference

User-preference description adopts the structure of TVAF and MPEG-7 MDS. The user-preference is composed of Usage History DS and User-Preference DS; the former gives an account of a usage history in a defined time period. The collected usage history can supply a user's action list. The latter describes user-preference descriptions correlated with the media descriptions to search, filter, select, and consume contents[9].

In the agent system, UPA checks usage history and records it in the XML schema of Usage History DS. Then User-Terminal generates the user-preference using a usage history. Using the preference, CMA and UPA filter user's desired contents. Those agents use statistical and rule based methods to generate and update user-preference. The method assigns a higher weighting value to the usage history of the latest week and uses content information such as an actor, a channel name, a genre, a content title, and watching time.

Fig. 5 represents an enhanced grid view of an xml file for three persons' user-preferences. The

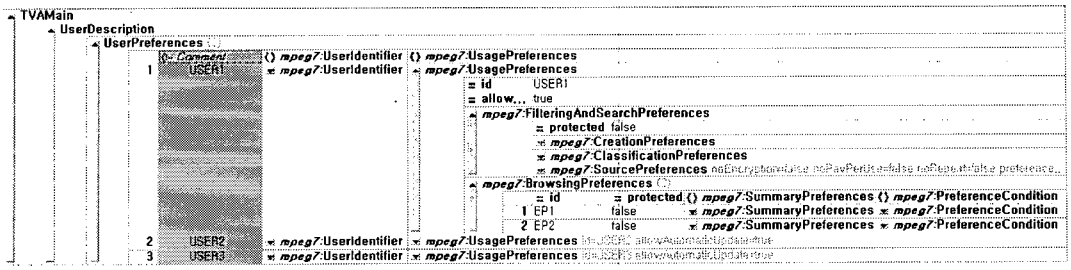


Fig. 5. Example of user-preference with three users.

figure shows the structure of user-preference used in the agent system. To filter and search broadcasting content, the proposed agent system utilizes FilteringAndSearchPreference DS, which describes the properties of the broadcasting content, *i.e.*, the creation related properties such as favorite actors or titles (CreationPreferences DS), the classification related properties such as preferred genre or language (ClassificationPreferences DS), and the source related properties such as a publisher or channel (SourcePreferences DS). The Browsing Preferences DS is adopted to specify a user's preference for navigating and accessing broadcasting content[10].

4.2 Metadata

In this paper, the representation of metadata basically follows the schemas of TVAF metadata: Content Description Metadata, Instance Description Metadata, Consumer Metadata, and Segmentation Metadata[10].

In the proposed agent system, an agent message, which is generated by Agent Communication Language (ACL) over Internet Inter ORB Protocol (IIOP), includes a metadata file or a user's intention. The message is transmitted through ACC of each agent platform. Therefore, we use the ACC as a return channel. The transmission structures of the metadata files adopt the metadata service types of TVAF: 'get_Data' Operation and 'submit_Data' Operation are utilized[12]. We extend the 'get_Data' Operation so that it is used to exchange query and response between User-Terminal and Service Provider.

4.3 Content Authoring

To provide the user-centric services to viewers, Service Provider agent platforms need a content-

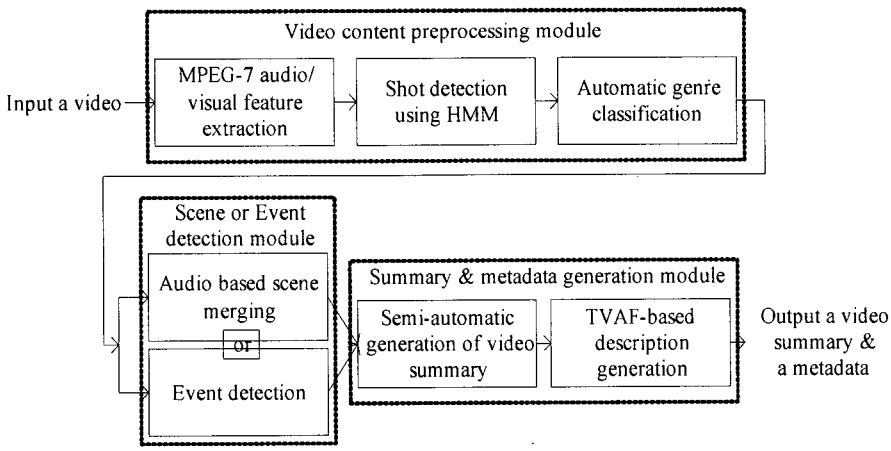


Fig. 6. The layout of a content authoring tool to generate video skims and metadata.

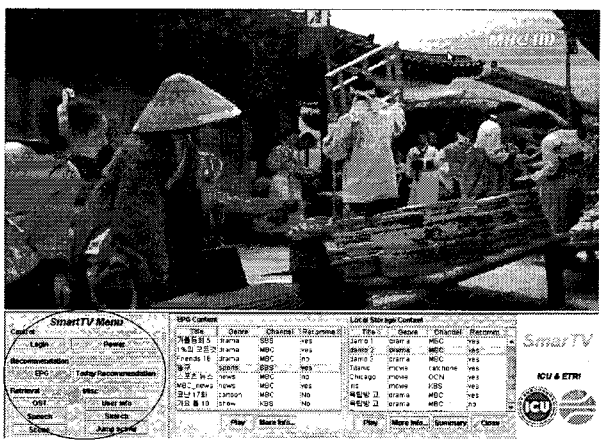
based authoring tool to generate video skim or metadata of original content. Fig. 6 shows the content based authoring tool, which is composed of video content preprocessing, semantic feature extraction, and video abstraction and metadata generation modules. After a video content is inputted, multimodal features are extracted using MPEG-7 descriptors in the preprocessing module. Then shots are detected and the video genre is identified using the features and shot analysis.

Next, the semantic feature extraction module is to detect scenes or meaningful events. In the agent system, event based video skimming is pertinent to summary video content. If the visual event detection is not available for certain content, audio continuity and homogeneity are used to merge the extracted shots into scenes. Finally, content providers generate a video skim by selecting the scenes or events and make TVAF based metadata to describe the input video.

5. EXPERIMENT AND DISCUSSION

We implemented the proposed agent system by using FIPA OS 2.1.0 and JDK 1.4.1.

As shown in Fig. 7, a TV viewer can transmit one's intention to the UIA of one's terminal through the Graphic User-Interface (GUI). The GUI offers multi interfaces to viewers for retrieving content and metadata by text keyword searching, image choosing, and speech recognition. It is controlled by the control menu located in the lower left side (the circled part) in Fig. 7 (a). The menu is divided into four parts: a control menu in which a user can log on or out, a recommendation menu in which a user can see content lists of EPG or local storage filtered by agents based on user's preference, a retrieval menu in which a user can search OST



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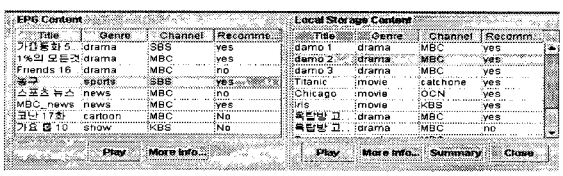

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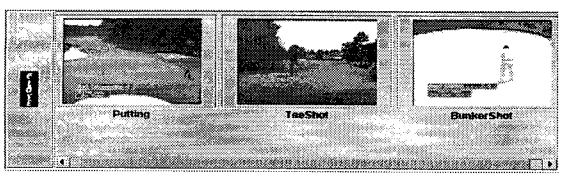


(c)

Fig. 7. Graphic User-Interfaces of a User-Terminal agent platform. (a) The GUI is controlled by the main control panel which has four parts: 'Control,' 'Recommendation,' 'Retrieval,' and 'Misc.' (b) When the 'Recommendation' is selected, the table shows content lists of EPG and local storage. The lists are filtered by agents with user-preference. (c) The panel shows an example of meaningful scene retrieval from a golf video through the 'Retrieval' menu. The retrieval can be performed by either speech recognition or image choice.

or meaningful scenes based on contents, and a miscellaneous menu, which is for inputting user's information and searching contents by using text keywords.

To demonstrate the proposed user-centric broadcasting services, we implemented a test-bed framework, which consisted of User-Terminals, Service Information Providers, and Service Providers over the IP network. In the framework, we assume EPG information, and broadcasting programs can be provided by the streaming servers of Service Providers. Therefore, an EPG server sends EPG information to all User-Terminals periodically. The video streaming server is multicasting according to the program list that has been recorded in. EPG.

In order to verify the intelligent user-information management service, one needs to check the update of user-preference and the change of the recommended content list by UPA and UIA. When several different persons use the same terminal, they can watch their own favorite live program on different channels and be served by a recommended content list depending on their preferences. Moreover, when one person does some action such as choosing content or an actor, one's preference is updated by UPA. Consequently, the user-adaptive watching environment could be provided in the framework. In the experiment, we found the adaptation result as shown in Fig. 7 (b). As the user-preference is updated by the agent, the orders of the lists shown in Fig. 7 (b) are changed.

For the information mobility service, we performed experiments to find the transmission of usage history and watching situation information through ACC, when a user moves to and utilizes an external User-Terminal. Using 'get_Data' Operation and 'submit_Data' Operation, the terminals exchanged the above information. Fig. 10 shows the enhanced grid view of the 'submit_Data' Operation. It includes a user's usage history in which actions performed at a home terminal are recorded. When one moves to a foreign terminal, the foreign terminal asks one's usage history from the home terminal by using the 'get_Data' Operation. Next, the home terminal transfers the history information by using the 'submit_Data' Operation. Then, the foreign terminal can use one's information about the latest watching situation of one's home terminal which is obtained from ActionTime element with 'stop' ActionType as shown in Fig. 8. Therefore, at the external terminal, one can consume the same content that one has watched at a home terminal previously.

As mentioned in the previous section, content and metadata authoring is essential to offer the content retrieval service in the framework. They adopt MPEG-7 multimodal techniques to support the proposed services. In experiments, we implemented the content authoring tool shown in Fig. 6. Table 1 describes the performance of shot

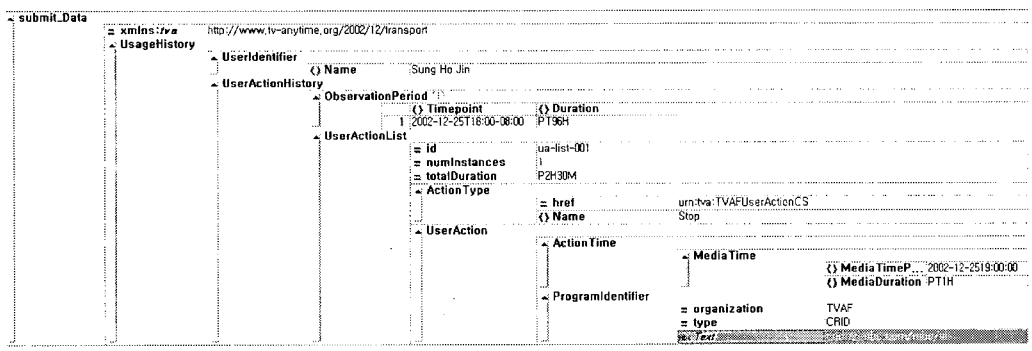


Fig. 8. Example of user-preference by 'submit Data' Operation for information mobility service.

detection technique using Hidden Marcov Process (HMM) and visual descriptors of MPEG-7 in the tool[14]. To verify the shot detection, we have used three video genres: news, golf, and drama of MPEG-7 video database.

In Table 2, we can see the results of the automatic genre classification technique using multimodal features and video database with five genres such as cartoon, drama, music video, news, and sports. To improve the classification performance correctly and faster, we used segmented short video clips with 60 seconds length [15]. By this classification, the authoring tool can provide event detection or scene merging[20-22].

Fig. 9 (a) shows the main view of the content authoring tool with which extracted shots are merged into scenes for generating video skim. As explained, using the video segmentation module, shots are extracted from input video, and further meaningful shots are selected by merging shots. The selected shots (with '1' value of 'Selected' item in the figure) are grouped and made into video skim. Using the extracted semantic information of content such as shots or events information, metadata are generated to describe the target content.

Fig. 9 (b) shows a metadata file about a video skim, which is generated semi automatically. The tree on the left side (①) of the figure shows the structure of a metadata file. One can edit and make metadata according to Summarization DS of MPEG-7. On the right side (②, ③) of the figure, one can see the key frames of the video skim and play the corresponding scene or event.

From the experimental results, we can see that the proposed agent system and key system components are suitable for supporting the user-centric broadcasting services.

6. CONCLUSIONS

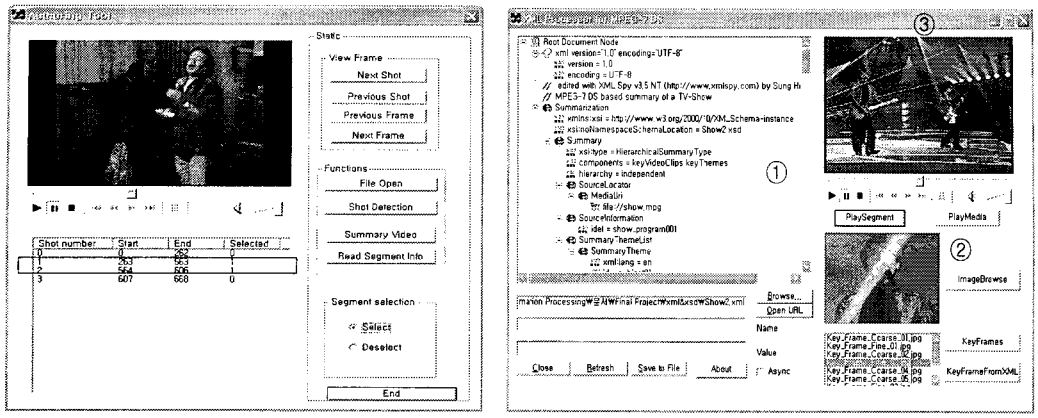
In this paper, we proposed a new user- centric broadcasting environment, which includes an intelligent agent system and personalized broadcasting services. For intelligent functions of the system, the agent technology from the FIPA is adopted. Moreover, to provide the user-based broadcasting services, MPEG-7 and TVAF standards are applied. In order to demonstrate the usefulness of the new broadcasting environment, we implemented a test-bed framework, which had several agent systems over the IP network. Through experiments with three services including intelligent user-information management service, information mobility service, and content retrieval service, the proposed agent system and services

Table 1. Shot detection performance in the authoring tool

Contents	Total number of shot boundary				Accuracy	
	Original	Correct	Missed	False	Recall	Precision
News	220	214	6	17	0.973	0.926
Golf	20	19	1	4	0.950	0.826
Drama	21	20	1	5	0.952	0.800

Table 2. The performance of automatic genre classification in the authoring tool

Predicted / Actual	Cartoon	Drama	Music Video	News	Sports
Cartoon	0.92	0.00	0.08	0.00	0.00
Drama	0.12	0.76	0.00	0.08	0.04
Music Video	0.00	0.00	0.96	0.00	0.04
News	0.08	0.04	0.00	0.88	0.00
Sports	0.04	0.00	0.04	0.00	0.92
Total correction rate		0.888			



(a) (b)

Fig. 9. The authoring tools for content retrieval service in the proposed agent system. (a) The tool to merge the extracted shots into scenes for generating a video skim. (b) The screen shot to generate metadata for describing the generated video skim according to Summarization DS of MPEG-7.

could be a new broadcasting environment which is more user-friendly and provides facilities to viewers for watching TV. In the future, the integration on a set top box for digital TV and fully automatic content authoring will be further investigated.

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Sung Ho Jin

He received the B.S. from Dept. of Electrical and Electronics Engineering in Chung-Ang University, Seoul, Korea and the M.S. from Dept. of Electronics Engineering in Information and Communications University (ICU), Daejeon, Korea in 2000 and 2002, respectively. Currently, he is a Ph.D candidate at ICU. His major interests are in video indexing and segmentation, image and video retrieval, multimodal technique, and MPEG-7 based broadcasting technologies.

Tae Meon Bae

He received the BS and MS degrees in electronic engineering from Kyungpook National University, Taegu, Korea in 1996 and 1998, respectively. He currently is pursuing the Ph. D. degree in Information and Communications University. His main interests are video indexing and content-based retrieval, video compression, wireless video streaming, and video watermarking.

Jun Ho Cho

He received the B.S. from Dept. of Electrical and Electronics Engineering in Chung-Ang University, Seoul, Korea in 2004. Currently, he is M.S. candidate at Dept. of Electronics Engineering in Information and Communications University (ICU), Daejeon, Korea. His major interests are in video indexing and segmentation, image and video retrieval, multimodal technique, and MPEG-7 based broadcasting technologies.

Yong Man Ro

He received the BS from Yonsei University, Seoul, Korea, in 1981 and the MS and Ph.D. degrees from the Korea Advanced Institute in Science and Technology (KAIST), in 1987 and 1992, respectively. In 1987, he was a staff associate at Columbia University, and from 1992 to 1995, he was a visiting researcher in University of California at Irvine and KAIST. In 1996, he was a research fellow at Department of EECS in University of California at Berkeley. In 1997 he joined Information and Communication University, Korea where he is currently associate professor and director of Image Video System Lab. His research interests include image/video processing, MPEG-7, MPEG-21, feature recognition, image/video indexing, and spectral analysis of image signal. He received the Young Investigator Finalist Award in ISMRM in 1992. He is a Senior member of IEEE and member of SPIE and ISMRM.

Kyeongok Kang

He received his B.S. and M.S. degrees both in physics from Pusan National University, Busan, Korea, in 1985 and 1988, and his PhD degree in electrical engineering from Hankuk Aviation University, Seoul, Korea, in 2004. He has been joined in ETRI since 1991, and he is now a principal member of engineering staff and the leader of 3D Media Research Team. His major interests are in personalized broadcasting technologies based on MPEG-7 and TV-Anytime, audio signal processing including 3D audio.