Designing Ubiquitous Personalized TV-Anytime Services

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Abstract. In this paper we present the design of an environment that offers personalized, ubiquitous information services in the emerging integrated world of the digital-TV and the Internet. This environment is based on extended TV sets with a large capacity disk and Internet connection. We present an architecture that integrates external service providers that provide extended information services about broadcasts with powerful retrieval, personalization and ubiquitous access capabilities. We assume that the metadata information about the content of the TV programs follows the TV-anytime Forum Metadata (TVAM) specifications. The architecture allows content based matching and/or retrieval based on the description of the broadcast or parts of the broadcast according to the interests of the viewers. The viewer has access to his/her "personal channel" any time not only from home, but also while on move. It is obvious that due to communication, storage and processing limitations of handy devices, it is not possible to access normal digital-TV content. Thus, special mechanisms that filter and appropriately adapt the content are necessary, in order to meet user's preferences and make its delivery and presentation feasible on the handy devices.

1 Introduction

In the near future thousands of digital TV channels will be broadcasting all over the world. These channels will provide links to information in the Internet, thus integrating broadcasting with a point-to-point communication medium.

In this paper we present the design of an architecture that adopts TV-anytime Forum Metadata (TVAM) specifications [6] and offers personalized ubiquitous information services. In a TV-Anytime environment the use of a consumer device that includes high-capacity disk storage is necessary as an extension to the TV set. Recording of programs or parts of programs can be made in the local consumer device or by the service provider to reduce the total equipment cost and to capture more programs than those that would be able to capture in a single consumer device due to antenna and parallel channel capturing limitations. An implementation of the above architecture has been carried out in the context of the UP-TV EU project (IST-1999-20751) [5] involving partners from the broadcasting, the telecommunication and the computer industry. The work that has been carried out is related to the provision

of services that can support many types of clients (including handy devices, mobile phones, PDAs, PDRs), perform quality adaptations and host user content and services. The UP-TV system provides personalized access to broadband information in an interactive way allowing the user to browse through the content, search for selected content items and organize the content in various ways. The middleware can also work to make automatic selection of TV programs or parts of programs. The UP-TV middleware can be part of the Personal Digital Recorder device (single use system) or can be integrated in server systems for in-house and last mile applications. The basic structure of the UP-TV platform is based on a client-server model, derived from reference architectures of TV Anytime services.

1.1 TV-Anytime Overview

The TV-Anytime Forum (TVA, [4]) is an association of organizations which seeks to develop specifications to enable audio-visual and other services based on mass-market high volume digital storage in consumer platforms. These specifications aim to enable applications to exploit the storage capabilities in consumer platforms and help the development of interoperable, integrated and secure systems from content providers, through service providers to the consumers.

The term metadata means descriptive data about content, such as program title and synopsis. In *TV-Anytime* program metadata [6] describe the audio-visual content in a formal way and allows the consumer or intelligent agents to find, navigate and manage content from a variety of internal and external sources including, for example, enhanced broadcast, interactive TV, Internet and local storage.

Segmentation is also included in TVAM [6] and refers to the ability to define, access and manipulate temporal intervals (i.e., segments) within an AV stream. By associating metadata with segments and segment groups, it is possible to restructure and re-purpose an input AV stream to generate alternative consumption and navigation modes including summaries of the content with highlights, or a set of bookmarks that point to "topic headings" within the stream. Such metadata can be provided by service providers or broadcasters as a value-added feature, and/or generated by viewers themselves. Considering the fact that when people use their mobile devices, they generally restrict their viewing time on the limited displays and minimize the amount of interaction and navigation, the segmentation can be considered as a major functionality expected for mobile support.

Metadata as defined by TV-Anytime also includes information about user preferences and usage history. User preference information, such as favorite actors or TV shows, is included within the scope of TV-Anytime metadata to allow software agents to select content on the consumer's behalf.

In order to select the optimum contents and to reduce the amounts of transmission data (especially in case of mobile users) summary and browsing user preferences can be used to access summary content (visual, audio, text). Summary content contains a collection of TV-Anytime descriptions to be used for customization or selection of user-required content at a mobile terminal as well as a set of key-frames or key texts each of which represents a key event in the content. It may also contain descriptions that can be used in content adaptation tasks. A summary of a Program is an abstract of

the content of the Program with respect to the interests of a user or a user group. This means that in order to construct a useful summary one has to take into account the information needs and context of the users that he wants to address and provide them with a comprehensive abstraction of the actual content of the program while preserving the essence of the content.

1.2 Related work

The research and development activities reported in this paper address mainly the issue of providing mutli-channel delivery of personalized TV-anytime services including remote administration of a set-top box, construction of personalized EPGs using TV-anytime content and consumer metadata and video browsing through appropriate summaries.

To the best of our knowledge, there is no such implementation based on TV-Anytime specifications. In [1] a similar environment is described based on MPEG-7 and not TV-Anytime metadata specifications. It lacks services of remote administration and personalized EPGs, providing only video summarization and browsing using pervasive mobile devices.

The TV-Anytime compliant system implementation described in [2] refers to work related with two EU funded projects, STOREit and myTV. Nevertheless that work focuses only on the software components and related issues pertaining on the PDR and not on mobile devices. It emphasizes on automatic filtering and selection of programs to be recorded in the PDR as well as using segmentation information to provide target advertising.

1.3 Paper Organization

In section 2 we present the whole system architecture that was designed and developed to provide ubiquitous personalized TV-Anytime services. We present the system components and the necessary middleware that was built to interface different subsystems. In section 3 we focus on services and applications that where developed to support the ubiquitous access. The remote administration applications developed for java-enabled mobile phones (section 3.1.1) and PDA's (section 3.1.2) are described. The concept of mobile user profile is presented (section 3.2) as well as the mechanisms developed (summarization, content and service adaptation) to provide access to user's personal channel (section 3.3). Finally in section 4 we summarize and present important conclusions of the work described in this paper.

2 The System Architecture

TV-Anytime specifications focus in the Personal Digital Recorder (PDR). The PDR is a consumer device that includes high capacity disk storage allowing content recording and opens the possibility of a new range of digital-TV applications and services.

The aim of our work was to develop an advanced information system environment where users could navigate, filter and have access to digital TV content via different communication links and diverse devices like mobile phones, PDAs, PCs and PDRs.

The UP-TV system consists of many servers that could be running in the PDR at home (small scale) or in powerful systems with high storage capacity and capabilities. The system follows a multi-tier architecture. The lowest tier handles the metadata management. The middleware tier includes all the logic for interfacing the system with the outside world. The application tier enables the exchange of information between the server and heterogeneous clients through different communication links.

The complete architecture of the UP-TV system is presented in fig. 1. The system consists of the relational database that holds all the TVAM information and the RDBMS that manages the transactional access to the database. A Java API has been developed that exports the available functionality of filtering, retrieval and summary services and cooperates with the XML-DB middleware that takes over the processing of TVAM XML documents.

Java servlets exist on the top of the system that form the front-end of the server and are able to accept client connections. The front-end of the system embodies special software that automatically recognizes the kind of the device requested service and appropriately adapts the information that can be exchanged and the functionality that can be provided.

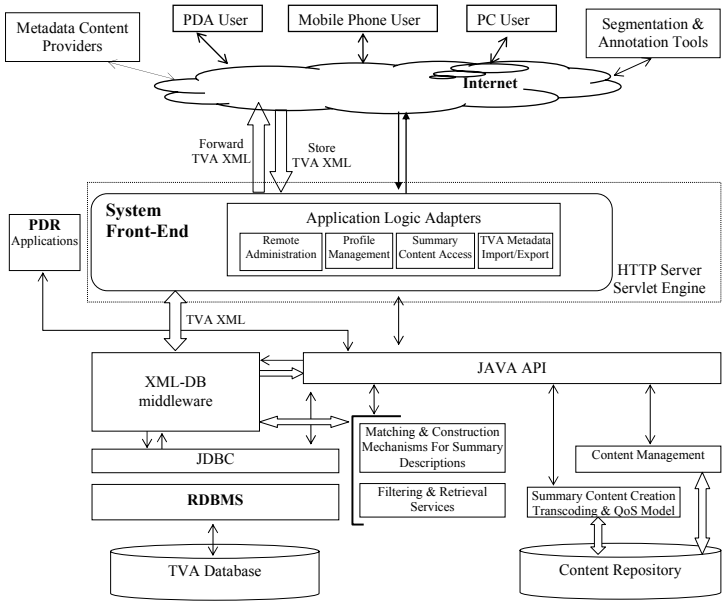


Fig. 1. Overall UP-TV System Architecture

During development process the HTTP protocol was found to be an excellent candidate for the communication of all devices. The client establishes an http

connection with the server no matter what device he is using (mobile phone, PDA, PC). This is a flexible approach since via this connection the client can exchange XML documents (storage-retrieval of TVAM documents, data structured in XML), serializable java objects (request-reply objects) or HTML depending to the device and the service that is being used. The front-end servlet accepts the HTTP requests, recognizes the device and the service requested, process the requests using the functionality of the Java API and the XML-DB module and sends the appropriate responses.

The core of the system is the metadata management middleware that takes over the storage of TVAM program and user metadata descriptions and provides advanced information access and efficient personalization services.

In the following we present the design and the implementation decisions that we made during the development process. The implementation was based on the following deci-sions:

1. The metadata management system should be able to receive and create all kinds of valid XML documents with respect to the TVAM XML Schema.
2. The database management system should follow the relational model and support the SQL standard as the language for data manipulation and retrieval, in order to be easily integrated with additional information in the servers, allow concurrent access etc.

The proposed architecture combines mature technologies to provide integrated solutions for the management of TVAM for programs and users. The solutions developed include functionality for storing the program metadata into relational databases, function-ality for storing TVAM consumer metadata into databases and functionality for retrieving data from the relational databases and assembling valid TVAM documents or document fragments. Mapping the TVA XML structure onto relational databases provides efficient mechanisms for matching program and profile metadata as well as user profile adaptation and data mining in viewing histories through the use of the SQL language, thus facilitating the implementation of powerful services for both the final users and the service providers. The XML-DB middle-ware (figure 1) is a set of software components responsible for the manipulation of TVAM XML documents and the mapping of TVAM XML Schema to the underlying relational schema. It is supported by a relational database management system along with the relational database, used to store the data of TVA metadata descriptions.
TVAM compliant clients use XML documents to communicate with the system. These documents contain data that could be used in conjunction with data from other TVAM XML documents. Document (or document fragment) retrieval is supported by a special purpose Application Programmatic Interface (API).

As depicted in Fig.1 the system's front-end consisting of java servlets contains the application logic adapters that handle the device-specific interaction with the clients and support various applications like remote administration, profile management, summary content access and import/export of TVAM XML documents. Applications running on PDR (administration, profile management, browsing) can bypass this level and have access immediately to the java API and the XML-DB middleware. The PDR can be accessed remotely using the internet connection. The system is able to accept TVA compliant XML documents from content metadata providers, process and store them in the relational database. The system also can accept segmentation information

from a segmentation tool that has been developed or from other existing tools that are capable of producing valid TVA XML documents with segmentation information. This information is the input for the system modules that implement the mechanisms to support the construction and matching of personalized content summary descriptions.

These descriptions represented as TVA XML documents (Segment Group Information) are used by the Summary content creation module that has access in the content repository, for the summary content creation. In order to handle video/audio streaming to the user's mobile device when a specific summary is going to be presented it is necessary to transcode the content of a video/audio summary to the appropriate file format taking also into account the particular capabilities of the mobile device (context) and the connecting network. This is handled by the summary content transcoding module, which prepares the appropriate files for streaming or downloading. Streaming issues in such heterogeneous client environments have been studied in [3].

Finally, remote users using diverse devices can access the PDR and perform the necessary administration tasks, manage their profile, and have access to their personal channel by determining their preferences and viewing the adapted personalized content summaries.

3 Providing Ubiquitous Access through Multi-Channel Communication Links

The user of a system that aims to support advanced digital TV services, should be able to have access and manage his PDR remotely anytime – anywhere. The following sections describe the mechanisms developed for the remote access of personalized TV-Anytime services via mobile cellular phones, PDA devices or normal PCs via web.

As already described the main aim of the system is to accept and distribute TVA XML documents. In previous section we presented the way the XML-DB middleware works to handle the storage and retrieval of TVA documents into or from the relational database. The system is capable not only to retrieve the XML documents actually stored in database, but can also produce and/or construct new TVA valid XML document containing either a projection of the available information or combined information required to satisfy a user query (e.g. program search, EPG, programs satisfying user profile, etc.). Using an HTTP server the system can accept TVA XML documents, process and store them in the database, while at the same time users can trigger, (by issuing the appropriate requests) the construction of TVA XML documents (containing the required information) and the delivery through an HTTP connection. In this way the system acts as a web service offering TV-anytime information services to various users through multi-channel communication links.

3.1 Remote Administration Application

This application approximates a workflow that is related to the remote administration of a PDR from distance. Two cases are considered related to the wireless device used. The first one is the application that is run able on any Java-enabled mobile phone device and the second one is the application that is run able on a PDA device. In both cases the remote management of the PDR allows a consumer:

- to manage his/her selection list (i.e. programs that have been selected by the PDR or the user himself as candidates for recording). The user can also see or even change appropriately the current status of the selection list programs. He can also search for a specific program of his selection list based on the title, genre and keywords.
- to manage the content already stored in the PDR. The user can browse or even delete content that is already stored. He can also search for a specific stored program based on the title, genre and keywords.
- to explicitly search the program metadata which are available at the PDR or a Remote UP-TV Server. The search is again based on program's title, genre, and keywords. Based on the search results the user can then add specific programs to his selection list.

3.1.1 Mobile Phone User

With the introduction of J2ME ([8]) the role of mobile wireless devices was enhanced from voice-oriented communication devices with limited functionality into extensible Internet-enabled devices. The use of Java Technology makes the application adequate for dynamic delivery of content, provides satisfactory user interactivity, ensures cross-platform compatibility and allows offline access. Allowing applications to be used without active network connection is of great importance since it reduces the transport costs and alleviates the impact of possible network failures. The J2ME architecture defines configurations, profiles and optional packages as elements for building complete Java runtime environments that meet the requirements for a broad range of devices and target markets.

Considering the above and in order to achieve the remote access and management via cellular phones we decided to take advantage of the J2ME technology and we developed a java application following the Mobile Information Device (MIDP) profile.

There are two types of wireless data networks in the market that the MIDP specification addresses: The circuit–switched data (e.g. GSM cellular network) where a dedicated connection is defined until the completion of the data transfer and the packet-switched data (e.g. GPRS) where the data exchange is broken up into small packets. Usually the data transfer over circuit-switched networks is billed on a time basis and since the data rates are relatively small this approach is rather expensive, while on the other hand transfer over packet-switched networks is billed by the amount of data sent. The design of the mobile application for the remote management should take into account both data networks, trying to reduce communication costs.

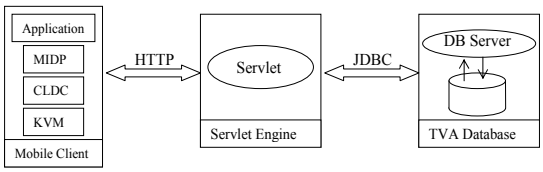


Fig. 2. Mobile client- server communication scheme

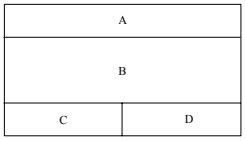


Fig. 3. The MIDlet UI design

The MIDP profile supports only HTTP as network protocol, a positive fact that coincides with our decision to use HTTP for the transport of TVA XML data. Implementing the communication scheme, we exploited the JAVA servlet technology in the server part, by introducing a servlet that acts as a gateway enriched with the appropriate information adaptation software between the mobile phone application and the RDBMS. Fig.2 shows the communication scheme developed to support users using cell phones.

Fig. 3 presents the design of the mobile user interface for remote access. The application uses a uniform design for all the screens that export the aforementioned functionality. Each screen is divided in 4 parts. Part A is used for the title of the current screen, part B is used for the presentation of the contents that are related to the functionality offered by the current screen, part C is used for the screen navigation commands (“continue”, “back”, “quit”). This part may only contain two of these commands each time. Part D contains commands for selecting the content, which is presented in the Part B of the screen (e.g. if B contains a list, then D is the Select Command).

In fig.4 some screenshots of the MIDlet that runs to support the following scenario are presented: A user using his java-enabled mobile phone wants to check and manage his selection list at his home PDR. First the user is connected to his home PDR (1^{st} screen), enters his account information (2^{nd} screen) and provides his preferences (3^{rd} screen). Then he checks the status of his selection list (4^{th}-5^{th} screen) to find out what has been recorded or is scheduled to be recorded by his PDR. The selection list is presented containing the title and the status for each one of the programs (5^{th} screen). The user can update the status of a program in the selection list or can see more details of a selected program (7^{th}-8^{th} screen).

Fig. 4. Indicative screenshots of the MIDlet UI

3.1.2 PDA User

The aforementioned approach was also followed during the development process to support mobile users with PDA devices. In this case the personal java profile was chosen for the implementation of the PDA application in order to provide advanced functionality exploiting the capabilities of modern PDA devices, while the communication scheme remains the same using the HTTP.

Fig. 5 shows some screenshots from the PDA application for the remote management of the PDR. The PDA user can connect to his home PDR (or to another UP-TV server) by providing his login information. Through the PDA application the user can search information for specific programs, access and manage his selection list and browse the stored content in his PDR. The 4th screen (fig. 5) depicts the way the program results are presented to the user after an explicit search by title. The user has also the ability to see detailed information for a specific program and insert it in his selection list. The selection list of the user is presented in 5th screen. The system automatically updates the user's selection list with programs that match the user preferences and also provides a rank value for each program that indicates how much a specific program conforms to the user preferences. The user through the application can change the status of programs or even the system ranking value.

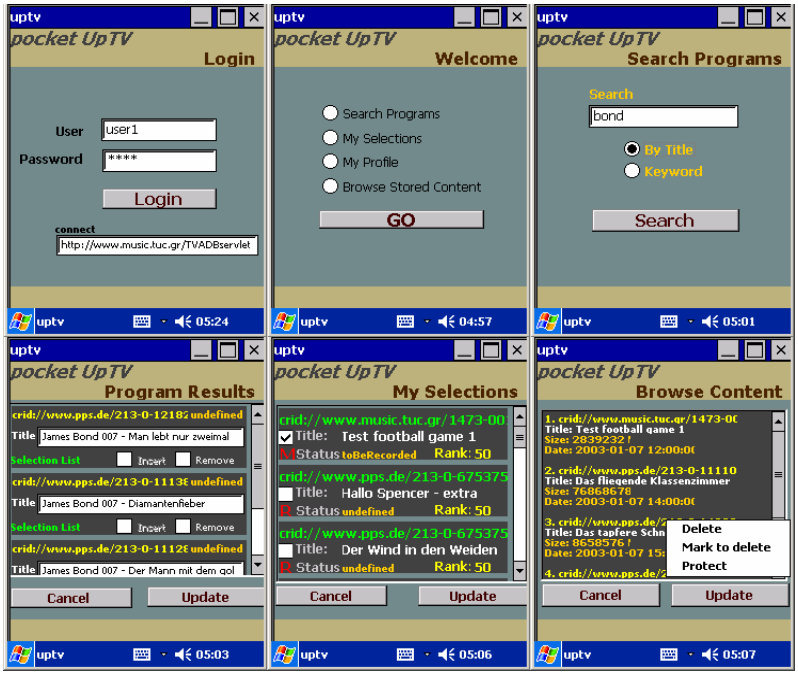


Fig. 5. Indicative screenshots of the PDA UI

3.2 Mobile user profile

The UP-TV system has adopted a model that allows the TV-anytime server to provide not only a time independent access to media information but also an access that is independent from place and client device. In order to support it the system is enhanced with appropriate methods, data models and interaction protocols that allow the user to be served not only from a single isolated system but also from different servers, in different places within a larger network. In general, an end user planning to move to other places can provide to its local system his/her destination (or a whole path of destination points) and the system will take care of migrating user related information (profile, descriptors of the recorded material) to a system close to user destination. In addition, the user can instruct for the downloading of specific programs to the destination server and can be informed, from anywhere and any device about what has been recorded for him.

The mobile user profile model is based on a Where, When, What and How structure, where any of these four aspects is optional. These aspects are handled using the Description Schemes that TV-Anytime offers for modeling user preferences. The PreferenceCondition DS handles the *where* and *when* aspects of mobility, i.e. the source, intermediate and destination locations of the mobile user in the UP-TV environment. FilteringAndSearchPreferences DS handles the *what* aspect of mobility,

i.e. hints on what to be recorded and downloaded on the previous mentioned locations. Finally the BrowsingPreferences DS handles the *how* aspect of mobility, i.e. preferences pertaining to navigation of and access to content. In particular, a user may express preferences about the type and content of summaries. These preferences may be conditioned on certain times, locations, and type of multimedia content in terms of genre. For example, a user may prefer a key-frame summary containing a limited number of key-frames. Similarly, a user may prefer audio skims of a particular duration as he/she receives the information in his/her car. Last, a user may prefer to visualize summaries based on key-videoclips with a duration between 5 and 10 minutes while in the office, or a visualization based on a limited number of key-frames (less than 50) at 5 pm, while on the train or in his/her car.

3.3 Personal Channel

As mentioned in the previous section the user should have access to his personal channel (i.e. programs that have been broadcasted and are recorded based to his preferences) even through the use of handheld devices while on move. It is obvious that due to communication, storage and processing limitations of such devices, it is not possible to access normal digital-TV content. Thus, special mechanisms that filter and appropriately adapt the content are necessary, in order to meet user's preferences and make its delivery and presentation feasible on the mobile devices.

A summary is a comprehensive abstraction of the actual content based on the user preferences. Focusing in the MPEG-7 specification of summary preferences that have been also adopted by the TVAF, different types of summaries (visual, audio, text) can be determined that could be available for users in the UP-TV mobile environment.

One strict requirement for UP-TV mobile environment is that user summary preferences should be taken into account when constructing summaries of content since it is the only way to specify what he/she wants to see and how.

The second requirement is that the TV-Anytime segmentation model should be used for the construction and description of summaries. TV-Anytime does not support a separate summarization model relying on the segmentation model for summaries of content. In order to do so, the specific interpretation of segments and segment groups to provide summaries should be specified. For the UP-TV system a summary consists of one or more segments that define the parts of the Program (or Program Group) that constitute the summary. It is possible to organize hierarchical summaries using different levels of segmentation groups. In this case, the segments that are at the leaves of the hierarchy are the most detailed summary while segment groups near the root of the hierarchy correspond to less detailed summaries.

In order to construct summaries for a user (or for a group of users) the UP-TV system should be given:

- Segmentation information for the programs or program groups that are going to be summarized.
- Summary preferences for the user.

Given the above, the first step is to locate the segments that represent the most useful content for the user. For this action, the segmentation metadata is used and a matching process is energized that matches the summary themes of the summary

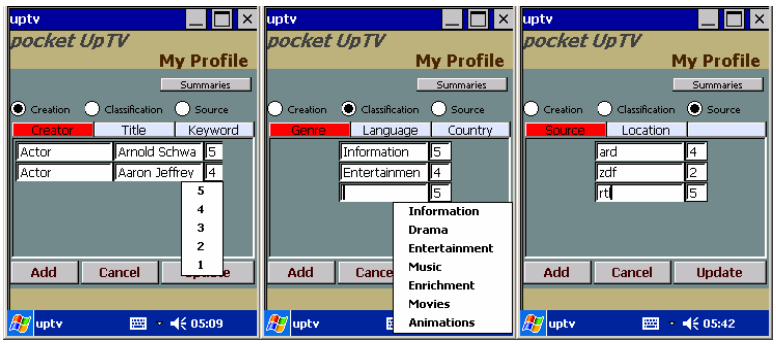
preferences of the user with the keywords, synopses and titles of the segments and segment groups corresponding to the segmentation information for the programs or program groups in consideration. The matching process results in ranked lists of segments, one list for each individual summary preferences of the user. Then, each list is examined and the top ranked segments are selected to be included in the corresponding summary so that the length of the summary is within the limits specified by the user. The selected segments are grouped together in a new *SegmentGroup* that corresponds to the summary created and the associated metadata are specified and stored. This metadata information can then be used to retrieve the summaries.

Finally, if the summary is an audio, visual or audiovisual one, the actual content of the summary is extracted out of the initial program or program group and appropriately processed so that the user can consume it.

3.3.1 QoS mechanisms

Summaries of audiovisual content, either constructed for a specific user or for a general audience, should be searchable so that users browsing with their mobile devices can receive these summaries whenever they actually want them. To do so, the metadata associated with the segment groups that represent the summaries should be matched with the user's summary preferences and, in addition, specify which particular program or programs should be given in summary form.

As already mentioned a summary is represented by a TV-Anytime *SegmentGroup* metadata description. These metadata are extracted as XML documents via XML-DB middleware and are sent as input to the summary content creation module that creates the summary content described in the XML document (MPEG-2 encoded video files used for visual, audiovisual content; MPEG1 layer 3 (MP3) encoded sound files used for audio-only content; JPEG Image Files used for KeyFrames content). This Summary content is adapted (if necessary) by the summary transcoding module to meet the user browsing preferences.



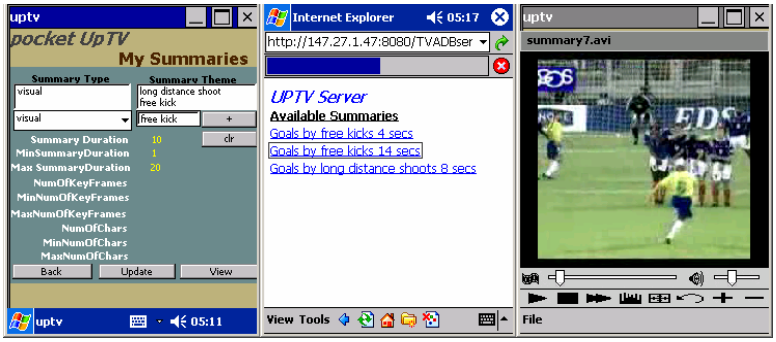


Fig. 6. Indicative Screenshots of the PDA application for profile management and summary browsing

3.3.2 Profile management & Summary browsing on the move

In figure 6 some screenshots of the PDA application are presented, that show the capability of constructing a user profile using the PDA device (or updating the user profile in his PDR remotely).

The user can easily set his preferences about the creation, classification and dissemination source properties of the programs. In each category the user can insert many different preferences and also the corresponding preference values. The UI provides to the user a small subset of what TVA specification can provide (Filtering and Search preferences) suitable for the needs of a mobile user using the PDA device. When the user finishes with the setup of his preferences a valid TVA XML document is constructed that can be transferred to his PDR or to another UP-TV server.

One of the most interesting functionalities of the implemented system is the capability of a PDA user to ask for summaries of content based on his browsing and summary preferences that also can be declared or updated from the PDA device. An example can be seen in figure 6 in the 4th screenshot where the user sets the appropriate parameters for visual summaries and asks the server for available video summaries that exist or can be constructed in real time. The server returns the results (5th screenshot) and the user can choose to download (or stream) and watch a video summary using an MPEG-4 codec in his PDA device.

4 Summary and Conclusions

In this paper we presented a system architecture for providing ubiquitous personalized information services in a digital-TV environment. Our main concern during development process was to conform with the TV-anytime specifications in order to support interoperability. We proposed a metadata management sub-system that is supported by a relational DBMS and adopts the TV-anytime metadata specification. Special middleware components are implemented on top of the relational database that offer efficient filtering and retrieval services as well as effective handling and processing of TV-anytime XML documents. The use of a

relational database system, offers useful capabilities like transactional support **(t**his is necessary in a multi-client fault tolerant environment), efficiency, security and advanced data processing (data mining tools and various SQL processing techniques offer the possibility to easily implement services, like matching user preferences with program metadata, adaptation of user preferences using usage histories, data mining on top of consumer metadata to provide marketing and targeting information).

Based on this powerful metadata management sub-system special software modules were built to offer ubiquitous multi-channel access and delivery of content. The users using a variety of diverse devices (mobile phones, PDAs, laptops, PCs) can manage remotely their PDR, search for programs, transfer their profiles and have access to their personal channel (through the efficient summary mechanisms), in a transparent way.

The implementation of special applications for mobile phones and PDAs was necessary to test our approach in real conditions and reveal system limitations. The development process led to various fine-tunings of the system architecture. The successful trial of the system during the UP-TV project activities ensures the feasibility of such an advanced digital-TV environment.

The interoperability of the developed system and its compatibility with the TV-anytime metadata specification were presented and demonstrated in the TVAF implementers' workshop [7].

5 Acknowledgements

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