Personalized and Ubiquitous Information Services for TV Programs

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Abstract

We present an overview of on-going research, system design and middleware that has been implemented on top of a relational DBMS to provide advanced personalized information services in an integrated digital TV and Internet environment. The middleware provides automatic selection of programs or parts of programs based on users' preferences. It is compatible to the TV-Anytime Forum specifications for user and program metadata providing extended capabilities for information retrieval using the Extended Boolean model. Adaptation of preferences based on users' viewing histories is also supported as well as the integration of domain specific ontologies to metadata standards. The metadata are managed robustly by a relational dbms allowing concurrency, remote access and modification. The system design and implementation emphasizes the use of standards (like TV-Anytime, MPEG-7, XML) for interfacing with the open outside world. Video is accessed based on its content and delivered in a variety of delivering channels including TVs, PCs, mobiles and PDAs.

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. Although Electronic Program Guides (EPGs) accessible from the Internet may help viewers to select the programs to watch, they are really limited in that they require a lot of time to be scanned by a human and that the information that they currently provide is inadequate for good selection. In addition, for many types of TV programs, the viewers may not want to see the whole program but only selected parts of it. Even if the EPGs were evolving to overcome their current limitations, they would not still be able to deal with the problem of program transmission at inappropriate hours for the viewers.

Some major recent industry moves focus into removing the limitations of current digital TV capabilities. A major international forum in this context is the TV Anytime Forum (TVAF [4]). The forum envisions an environment where the traditional digital TV is expanded with a very large disk, which can store TV programs that the user may like (according to his profile). These programs may be broadcasted at odd hours (for example when the user is at home or he is sleeping). The TVA architecture also foresees last mile servers that accommodate TV programs and other multimedia data. International forecasting agencies project a very high acceptability for such a recording device, with profound implications for the whole industry and the emerging business models in the new environment (e.g. impact on advertising, etc.).

In this paper we describe middleware implementation on top of relational databases, which offers personalized, ubiquitous information services in the emerging integrated world of the digital TV and the Internet. The architecture assumes extended TV sets having a large capacity disk and Internet connection. The middleware integrates external service providers that provide extended information services about broadcasts with powerful, retrieval and personalization capabilities. Information about the content of the TV programs is encoded based on the metadata specification of the TVAF (TVAM [6]), and the middleware allows content based matching and/or retrieval based on the description of the whole broadcast or parts of the broadcast according to the interests of the viewers. An extended semantic retrieval capability based on an MPEG-7 augmented with domain specific ontologies models is also presented. The middleware also allows viewers to select and/ or see summaries of selected TV programs while on the move. All personalization mechanisms use SQL queries to implement similarity retrieval based on the Extended Boolean model [7]. Much of the research and development described in this paper was done in the context of the UP-TV EU Project (ISF1999-20751).) and we describe the proposed demonstration.

2. Middleware overview

The design and implementation of our system is based on the following principles:

1. We live today in the Internet world. The basic principle of cooperation in the Internet world is adherence to international standards in order to guarantee interoperability of the applications across the Internet and the spontaneous accommodation of new servers accessing the offered services. In our opinion it makes no sense to develop systems and algorithms in this environment based on proprietary standards. We have adopted all international standards in the communication of our system with the outside world including XML and its derivatives, as well as TVA and MPEG-7 for multimedia content descriptions.
2. The management of the multimedia metadata in the servers should be robust, accommodating fast retrieval, but also correct and efficient concurrent access from remote sites. We have adopted relational data base management system technology in the core of our system due to their mature nature, robust system and methodologies, query optimization, concurrency control and recovery.

These features are not offered currently by other alternatives. These two principles imply that there should be also support for efficient conversion of relational to XML structures within the server, and vice versa.

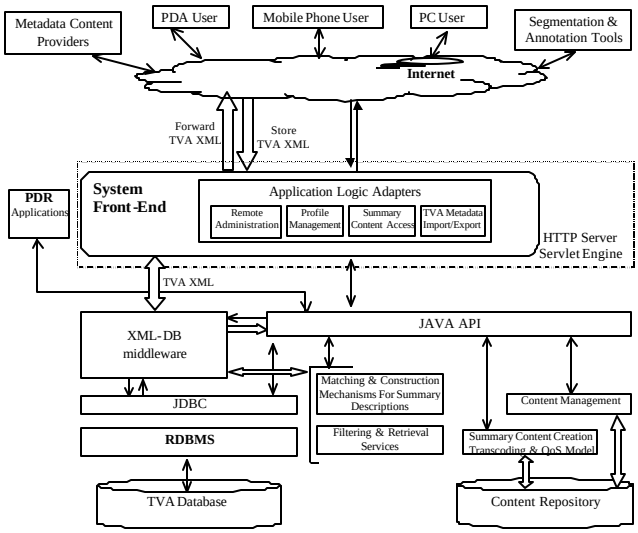

Figure 1: Overall System Architecture

The middleware 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 middleware can be part of the Personal Digital Recorder device (home system which allows remote access through the Internet) or can be integrated in server systems for in-house and last mile applications. The basic structure of the implementation platform is based on a client-server model, derived from reference architectures of TV Anytime services.

The overall system architecture and the components of the system are shown in figure 1. As is shown in the figure the software tools provide multi-channel access to multimedia information, and it also supports multiple remote users working for the segmentation and annotation of the multimedia information. The software supports all the basic operations to multimedia data like segmentation program and user metadata management for the multimedia data filtering, adaptation, summarization, transcoding, etc.

2.1 Mechanisms for content identification

The UP-TV middleware relies on TVAM specifications [6] for modeling content metadata, «filtering and search preferences» of the users and usage histories of the users. The salient aspects of the intelligent information filtering provided are as follows:

- TV programs as well as program segments are considered as Information Items described by a series of different feature types. Each feature type corresponds to a particular part of the program metadata description (e.g. the genre of the program is a feature type, etc.).
- Content Based Retrieval requests as well as user preferences associated with user profiles or stereotypes describing user groups are all modeled using the «filtering and search preferences» Descriptor Scheme from TVAM specification. Such filters are composed of all possible feature types. The result of the matching process is the set of Programs that satisfy the «filtering and search preferences».
- Collaborative Filtering requests rely on an estimation of similarity between users. This similarity is computed by the usage history and the «filtering and search preferences» of any pair of users. For a particular user, the system is able to recommend programs that users similar to him have already watched and liked.
- Combined retrieval requests use both content-based retrieval and collaborative filtering to retrieve programs and employ a weighted average scheme to compute a final preference weight for each program.

In order to support all the above functionality, the UP-TV middleware uses various kinds of preference and similarity estimations per user:

- Explicit content preferences provided by the user.
- Implicit content preferences that are inferred from the usage history of the user.
- Future content preference estimations resulting from the content based or collaborative filtering process.
- User similarity estimations used to find users with similar preferences with a particular user.

2.2 Mechanisms for content management and access

The UP-TV middleware provides sophisticated content management functions for the recorded content. The aim of these functions is to ease user navigation and provide functionality that goes far beyond current TV and VCR technologies, such as content-based search and content previewing (summaries). Providing such functionality is closely related to efficient handling and management of content metadata. The system includes a content metadata management middleware and sophisticated indexing mechanisms to access on the content level as well as management of segmentation metadata, semantic information and summarization.

The main characteristics of the content management middleware include: TVAM Content descriptions (program and segmentation metadata [6]), it is based on open source, light weight, RDBMS for easy porting and exploitation, and efficient optimizations have been implemented in order to achieve a high performance metadata management system. The middleware has been efficiently integrated with the metadata workflow management functionality to capture metadata from heterogeneous external providers. In addition various methods have been provided for accessing program information.

2.3 Integrating domain specific ontologies with the multimedia standards

The standards for the multimedia content descriptions do not provide currently explicit mechanisms or methodologies for the integration of domain specific ontologies with the metadata. However, such integration is very important since it will result in much better retrieval effectiveness in user queries and in filtering processes. We have developed a methodology and a framework for the integration of domain specific ontologies in MPEG-7 and TVA [3]. We opted for a strategy that utilizes pure MPEG-7 structures instead of sub-classing to describe the ontology so that we provide complete interoperability of applications.

Our methodology for ontology integration for MPEG-7 includes:

- Definition of the structure and legal values for each of the Description Schemes and the Event Types in a specific knowledge domain using XML Schema.
- Use of the Event Types to define Events that relate Agents with Place and Time.
- Definition of the ontologies using the attribute Abstraction Level of the Semantic Base Type (for Abstraction Level=1 and above)
- Definition of the reusable instances of objects using Abstraction level=0
- Description of the instances of the events in a video.

Ontologies are inserted in the system in XML Schema syntax by an ontology management tool. The ontologies, the object instances and the instances of the events in the video are stored in a relational database (as the other MPEG-7 metadata). The system provides APIs that support generic complex queries that use the ontologies [3]. A complete ontology for soccer games has been developed and integrated with MPEG-7 and TVA. Soccer games have been segmented, indexed and stored to show the capabilities of the system. Using the query interface a user can ask for example to see the segment that contains the goal that the player Ronaldo scored against the goalkeeper Mayers at the second half of the game Brasil against Germany at the 2002 FIFA World cup. Since the objects appearing in a video are associated with an ID, the user can ask for additional information that exists in the database about these objects, for example statistics on Ronaldo.

The TVA metadata model has also been extended to accommodate ontologies. However the basic structures provided by TVA for the support of ontologies are simpler (based on keywords). The segmentation tool coordinates the indexing process making sure that the user is always aware of the ontology legal values. The query tool is also aware of the ontology contents and the interface supports the user in the selection of legal ontology values.

2.4 Mechanisms for mobility support

From the end users point of view, mobility support refers to the ability of the user to have access to his/her "personal channel" not only from home, but also from other places (e.g. during business travels, etc.). The UP-TV middleware that provides mobility support includes the 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 service providers, in different places within a larger network. In general, an end user planning to move to other places can provide to its local UP-TV 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 an UP-TV system close to user destination.

The mechanisms developed include support for:

- The migration of the mobile user profile information to a destination server in order to satisfy the user preferences while at destination along with the capability for the user to browse/search program metadata of the destination server and/or makes explicit selections.
- The remote access of the UP-TV server and client devices (i.e. PDRs) through handy devices. The user can remotely manage the programs that have been selected by the PRD or the user himself as candidates for recording, search for a specific program of his selection list based on the title, genre and keywords, manage the content already stored in the PDR and explicitly search the program metadata which are available at the PDR or a Remote UP-TV Server.

- The content quality adaptation. It allows for the selection of different quality levels of content. The descriptors of content are also scaleable to different quality levels (fast views, miniatures, text). QoS adaptation and streaming techniques in heterogeneous environments have been also considered [2].

3. Implementation

The UP-TV system follows a multi-tier architecture [1]. 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 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. The implementation was based on the following decisions:

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 solutions developed include functionality for storing the program metadata into relational databases, functionality 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 TVAM 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 middleware (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).

In this environment the data management software should not rely on XML document modeling solutions (like DOM) but rather on a data binding approach. Data binding offers a much simpler approach to working with XML and supports effective separation between document structure and data modeling.

There are numerous XML data binding products capable of transferring data between XML documents and objects. Design-time binders (require configuration based on a DTD or an XML Schema before they can be used) are usually more flexible in the mappings they can support. The architecture in figure 1 assumes a design-time binder. Thus, a configuration process was necessary to create the appropriate classes. The XML data binder considered for the implementation of our system is data-centric. It is capable of fully representing XML documents as objects or objects as XML documents (the serialization of the object tree to XML document is encapsulated in class (un)marshal methods). The data binder uses a SAX-based parser and the corresponding validator can be used to ensure that incoming and outgoing XML documents conform to the TVAM XML schema.

The communication with the relational database management system relies on the use of standard interfaces like JDBC. Standard SQL statements are used to store-retrieve data from the underlying relational database. To do so, the classes created during the data binding configuration process are extended with DB-Insert/Retrieve methods. DBInsert methods use the object tree to create INSERT/UPDATE statements to give persistence to data of the object tree. These methods can also query the database to avoid duplicates of data. DBRetrieve methods retrieve data from the database with the objective to build object trees that could be used to create TVAM XML documents. The DB-Insert/ Retrieve methods rely on both the class hierarchy created by the data binding configuration process and the relational schema of the underlying database. The relational database is responsible for the storage and retrieval of information that is represented in TVAM XML documents.

In order to support ubiquitous access special device-specific components of middleware were developed for the UP-TV environment. For the application development in hand-held devices the Java technology was chosen since it is adequate for dynamic delivery of content, provides satisfactory user interactivity and ensures cross-platform compatibility. Two components were built, one suitable for cellular phones compatible with the MIDP profile and one for PDAs that support the Personal profile. In order to keep the communication scheme simple and uniform among different devices, we have chosen to use HTTP since it is suitable for the transfer of XML documents and is the network protocol supported by the MIDP libraries. The front-end of the server consists of Java servlets that accept HTTP requests from the clients and embody software adapters that adapt appropriately the information that will be exchanged and the functionality that can be provided, depending on the kind of the device that requested service.

4. Description of the Demonstrators

Currently available demonstrators offer the following functionality (see figure 2):

- Program metadata workflow management (metadata model, XSL transformations to support information providers with proprietary formats, interoperability with other TVAM data creation editing and management tools)
- Personalization services (user profile model, content-based and collaborative filtering, stereotype based information dissemination, extended boolean queries for explicit search, automatic profile determination and/or adaptation based on user action metadata)
- Methods for program access (retrieval of valid fragments of a TVAM document, assembly of valid TVAM documents from fragments)
- The segmentation tool providing capabilities for manual segmentation coordinates with transcription of the voice part of the video data and also with the ontology supporting mechanisms
- The semantic retrieval tool which allows the indexing of segments based on MPEG-7 and domain specific ontologies, as well as the powerfull retrieval possible with it. An application with soccer game ontologies and specific soccer games is shown.
- Ubiquitous access (remote access/administration using mobile phone or PDA, user profile management, summary selection and consumption using PDA)

Figure 2: Indicative screenshots of the UP-TV system

The interoperability of the middleware and its compatibility with the TVAF specifications were presented and tested in the TVA development workshop [8], and are currently used in an extensive trial in apartment buildings in Belgium.

5. Acknowledgements

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