Architecture of a system for the generation of personalized Electronic Program Guides*

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Abstract. With the expansion of digital networks and TV devices, people are exposed to an information overload, due to the presence of several hundreds of alternative programs to watch. Therefore, personalized TV listings services are needed to support the search for relevant options. This paper presents the multi-agent architecture of a system for the generation of adaptive EPGs, which filter the information about TV events depending on the user's interests, contextually to the vision time.

1 Introduction

With the recent explosion of TV content, digital TV networks and broadband, smarter TV entertainment is needed. As there are several hundreds of available programs every day, users need to easily find the interesting ones and watch such programs when they like it (i.e., by time shifting the events, automatically programming the VCR). Moreover, broadcasted programs do not represent distinct sets of options: some events, such as soccer games, are transmitted by different channels almost synchronously; other ones, such as movies, can be transmitted at different times. Rich Electronic Program Guides (EPGs) are needed [2, 6], where TV content is mixed with Internet content. For instance, detailed information about programs has to be available, as well as the possibility to let users get specific information by following hyper-links on the TV screen. Personalization [5] and user modeling techniques [12] are therefore key functionalities to be integrated in the TV service provisioning models, especially because TV sets are more and more similar to normal PCs: they usually support powerful software environments which offer JVMs, C compilers; in some cases, they are even equipped with fast CPUs such as Pentium.

* This paper follows-up and extends work done in two previous projects: Work Package A1 of FACTS, the ACTS AC103 project of the European Commission and the "Cantieri Multimediali" initiative, carried on at the Dipartimento di Informatica of the University of Torino under a grant funded by Telecom Italia. The described work has been partly funded by the EUROPA (End User Resident Open Platform Architecture) project inside the EUREKA/ITEA Programme.

Event Name: Star Trek: The enemy within
Start Time: 2000/12/02 20:00:00
Duration: 00:50:00
Content: Movie/Drama - Science Fiction/Fantasy/Horror
Language: ENG
Parental Rating: 11 years old
Short Event Descriptor: A must for old trekkies: transporter malfunction splits Kirk into an aggressive aspect and a timid one.

Fig. 1. DVB descriptor of a TV event.

This paper presents the architecture of a system which captures a model of each user and exploits it for the generation of adaptive EPGs; this system, currently under development, will also be used to suggest TV programs for VCR recording. The system is based on a multi-agent architecture, where specialized agents collect data about the available events, monitor the user's behavior to retrieve information about her/his interests and select the events to be advertised in the personalized EPG, depending on the user's preferences at the time of day s/he wants to watch TV. The system is located on the user's Set Top Box, where the tasks for the management of the EPGs are executed.

Our system exploits a TV events collector to download, from the satellite stream, information about the TV programs available in a restricted time interval (a couple of days). This component stores structured information about TV events into the local database of the Set Top Box, by integrating the data transmitted in the satellite stream with information about programs retrieved from alternative information sources. In this way, when the user switches on the television, an up-to-date, personalized EPG can be dynamically generated, on the basis of richer information than the one transmitted in the satellite stream. The integration of the two types of information is based on the exploitation of an ontology which extends the DVB (Digital Video Broadcasting) standard [7].

The paper is organized as follows: section 2 describes the representation of TV events and the collection of information about programs performed by our system. Section 3 presents the system architecture, while section 4 discusses some related work. Section 5 concludes the paper.

2 Representation of TV events

2.1 Digital Video Broadcasting (DVB)

As a detailed description of TV events is essential to the automatic generation of EPGs, the Digital Video Broadcasting standard [7] has been defined to specify data about TV programs. According to DVB, a TV event is described by a record which includes fields concerning different information: e.g., the starting time of the event and the stream content (type of the transmitted stream: video, audio or data). The standard also includes a field for the specification of one

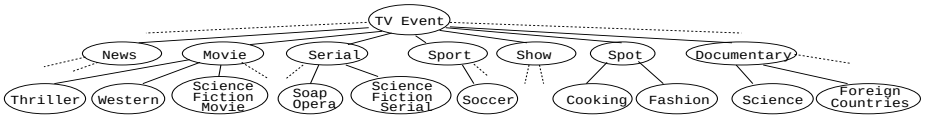

Fig. 2. Portion of the Domain Ontology representing TV events. Dotted lines mark the places where, for space reasons, we have omitted concepts.

or more content categories which characterize the event. The DVB categories range from movie to show, sport event, and so forth; see Figure 1, which shows a portion of a record describing a Star Trek episode. In principle, an EPG for a set of channels broadcasted by a provider could be generated by extracting from the satellite stream the DVB information about programs and by displaying it on the user's television. However, this task is much more difficult because the transmitted information is incomplete. Therefore, a satisfactory description of a program cannot be retrieved from the structured fields of its own DVB record.[1] Another problem is that the DVB categories are not sufficient for a selective recommendation of programs: most DVB categories represent broad classes of programs (e.g., movies), which can hardly be exploited to recommend programs satisfying specific interests (e.g., action films, or thrillers). This is probably the reason why several commercial systems for the generation of TV listings exploit specific information about TV programs, stored in private databases.

2.2 The Domain Ontology

Our TV Events Collector merges the information broadcasted in the satellite stream with data about TV programs, retrieved by other information sources. Such sources are the EPGs published on the broadcasters' Web sites, which typically contain more detailed and structured information than the one of the satellite stream. In order to integrate descriptions coming from heterogeneous sources, we have defined a Domain Ontology (see Figure 2), which extends the DVB standard with super and sub-categories, some of them replacing the standard ones. For instance, we have replaced the "Movie/Drama - Science Fiction/Fantasy/Horror" DVB category with a set of more detailed categories, which distinguish thrillers from action movies, westerns, and so forth. The Domain Ontology also adds new field descriptors to the DVB standard (e.g., directors and featuring of movies and serials). In addition to the DVB content perspective, we have considered the format of programs (e.g., movies vs. serials, documentaries vs. spot programs). Our analysis of TV events shows that certain formats constrain the content of programs: e.g., there are science

[1] While analyzing the satellite stream produced by some major Italian broadcasters, we discovered that the field descriptors are frequently void. Some more information is stored in the "Short Event Descriptor". However, a complex information retrieval activity must be performed to extract it, because it is written in Natural Language and does not conform to any standard template.

Event Name: Star Trek: The enemy within
Start Time: 2000/12/02 20:00:00
Duration: 00:50:00
Content: Science_Fiction_Serial
Director: Robert Gist, Marc Daniels
Featuring: Leonard Nimoy, William Shatner
Language: ENG
Parental Rating: 11 years old
Short Event Descriptor: A must for old trekkies: transporter malfunction splits Kirk into an aggressive aspect and a timid one.

Fig. 3. Descriptor of a TV event produced by our TV Events Collector.

fiction movies and serials, but soap operas are only present as serials. To address such differences, we have defined new ontology categories which distinguish the format of programs. For instance, the DVB "Movie" category is replaced by the "Movie" and "Serial" categories. Moreover, our "Movie" category has several sub-concepts, among which "Thriller", "Western" and "Science Fiction Movie". "Serial" has "Soap Opera" and "Science Fiction Serial" as two of its sub-concepts. The format is important to the suggestion of TV events because it helps to identify their audience. For instance, some formats are associated to recognizable quality standards: e.g., serials are typically lower quality events than movies. Moreover, some formats are related to precise watching habits: e.g., serials such as soap operas require people to watch all their episodes.

2.3 Collecting information about TV events

The TV Event Collector searches for information about TV events, fills in the event descriptors and stores them into the TV Events DB. The information about programs is collected by extracting DVB information from the satellite stream (MPEG2-TS) and parsing the broadcasters' Web pages to retrieve further information about content of programs, format and basic DVB-compliant information missing in the DVB records. The TV Event Collector exploits a set of mapping rules to translate the retrieved information into the concepts defined in the Domain Ontology: e.g., some rules relate event categories used by providers into those which we defined. The exploitation of different EPGs supports the generation of finer-grained event descriptors than the DVB ones (e.g., compare Figures 1 and 3). In fact, the ontologies implicitly adopted by the various broadcasters focus on different types of information and, by integrating them, richer descriptions are retrieved. For instance, some EPGs provide detailed information about movies and sport, leaving the other categories almost unspecified; other broadcasters distinguish documentaries in different sub-categories.

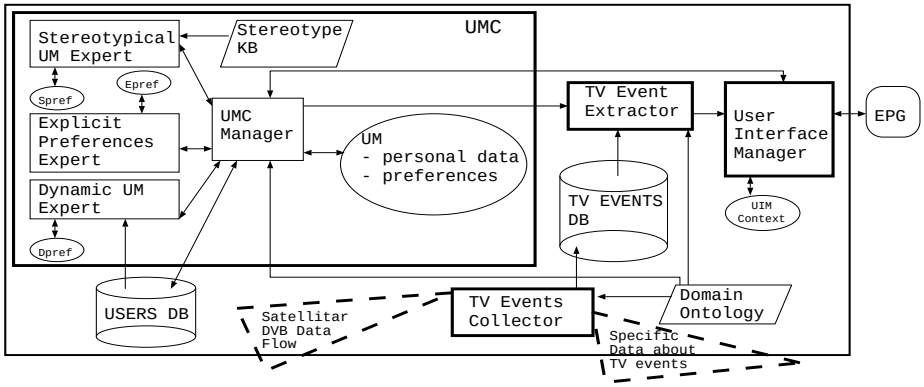

Fig. 4. The system architecture.

3 System architecture

The system resides in the user's Set Top Box and is based on a multi-agent architecture, where specialized agents cooperate to the generation of personalized EPGs on the user's TV device. The system uses Java-based MAS technologies for the agent distribution and communication [3]. Four main roles can be identified in the architecture and one agent is associated to each of them:

- collecting information about the available TV events;
- handling the interaction with the user, by generating and displaying the pages of the EPG on the TV screen, according to her/his requests;
- monitoring the user's behavior to get information about her/his interests;
- selecting events for the personalized EPG, on the basis of the user's preferences related to the time of day when s/he wants to watch television.

Figure 4 shows the system architecture: the main rectangle delimits the architecture and the rounded square shows the EPG to be displayed on the user's TV. The agents are represented by thick rectangles and the dynamic data structures which they manage are depicted as ellipses. The arrows represent the flow of data during the agents' activities (background collection of TV events and generation of EPG). The domain-specific knowledge is declaratively represented in knowledge bases (Stereotype KB, Domain Ontology), shown as parallelograms.

The **TV Event Collector** exploits the Domain Ontology (see Figure 2) to merge DVB information about TV programs with information stored in the broadcasters' Web pages. This agent is periodically activated to retrieve information about the programs available in a two days window and it stores the extended TV event descriptors into the TV Events DB.

The **User Interface Manager** handles the interaction with the user. At the current stage, we have focused on requests concerning the generation of an EPG (other actions, e.g., requests for specific information about TV events, will be considered). When the user asks for the EPG, the User Interface Manager sends

a message to the TV Event Extractor, asking for the generation of the EPG. The User Interface Manager maintains a context storing the current time of day and exploits it to specify the time window for the selection of the information to be displayed. The specification of this context supports the generation of EPGs related to different times of day. When the content of an EPG is selected, the User Interface Manager generates the pages of the guide and sends them to the TV screen. This agent also forwards to the User Modeling Component information about the user's actions on the EPG and the watched programs.

The **User Modeling Component (UMC)** includes a UMC Manager module, which maintains in the user model (UM) the user's data (name, age, etc.) and a consistent view of her/his preferences and watching behavior (user data and information about the watched programs are stored into the Users DB and can be retrieved during a TV session, to make inferences on the user's preferences). At the current stage, we assume that a TV is watched by a single user at a time: the user logs in by specifying a password; therefore, the system knows who is acting on the TV and can analyze her/his watching behavior without any interferences.[2] The user's preferences stored in the UM correspond to the types of program specified in the Domain Ontology.
The UM is filled in with the predictions of three user modeling modules: the Stereotypical UM Expert, the Explicit Preferences Expert and the Dynamic UM Expert. Each module stores its own predictions into a local context ("Spref", "Epref" and "Dpref" in Figure 4). The modules compete with each other and the UMC Manager merges their predictions on the basis of their confidence in each prediction and of an overall "reputation" measure, attributed to each module on the basis of its capability to correctly specify the user's preferences. The **Explicit Preferences Expert** maintains the preferences for programs and watching times declared by the user (by filling in an initial registration form, produced at the first interaction). The **Stereotypical UM Expert** produces a customized user model right from the first TV session, when no information about her/his watching behavior is available, except for her/his explicit preferences. This module exploits the user's personal data and declared preferences to classify her/him into a set of relevant user typologies and predict interests and watching behavior accordingly [1, 9]. The **Dynamic UM Expert** analyzes the user's watching behavior to identify her/his preferences for program categories and update its local user model ("Dpref") accordingly. This module also stores information about the most frequent keywords characterizing the programs watched by the user, in order to acquire precise information about the preferred programs, for each category of the Domain Ontology [4].

The **TV Event Extractor** retrieves the information about the available events of the TV Events DB, contextually to the time of day specified for the EPG. Our goal is to constrain the maximum number of events listed in the EPG and to display only the most relevant information, enabling the user to follow special links if she wants to access the other available programs. In this perspective, a virtual space (measured as a number of listed items) is devoted

[2] The management of family models is part of our future work.

to each program category, proportionally to the user's interest in the various categories of the Domain Ontology. In order to select the programs to be listed in each portion of the EPG, the TV Event Extractor ranks the available events on the basis of the user's preferences, estimated on the basis of the most frequent keywords occurring in the programs watched by the user [4].

4 Related work

Several information filtering tools are used to recommend items in Web-based services such as Web stores, electronic libraries and TV listings services; e.g., see [10, 13] and [8] for an overview. These systems, based on techniques such as collaborative and content-based filtering for personalizing the suggestion of items, are typically designed as monolithic architectures, which can hardly be modified, or integrated with new modules to enhance their functionalities. Although this is not a problem for the Web search applications they have been designed for, it limits their applicability to other domains. For instance, these systems run on central servers and store the information about users and products in their own databases. Some activities, e.g., collaborative filtering, can currently be performed only in a centralized way, but the decentralization of tasks is essential to the TV world, which imposes privacy issues on the treatment of the users' data and severe constraints on the time needed to download information.

Specific commercial systems have been developed for digital TV. For instance, the PTV Listings Service system [6] generates personalized EPGs accessed by browsers and WAP phones. The system is based on a centralized architecture and uses collaborative and case-based filtering techniques to select programs for the EPG. A profiler agent maintains information about the user's preferences for programs and other, more general preferences, concerning channels, watching time, etc.; as the profiler agent continuously tracks the user's behavior, real-time personalization of the EPG is supported. The Singularis S.3P system [15] generates personalized EPGs which can be accessed both on the Web and from the TV device. Moreover, it offers a personalized video recording facility to autonomously download on digital VCR the programs assumed to be of interest to the user. TiVo [16] and Replay TV [11] support a personalized management of digital VCRs, however, they differ in the type of preferences used for selecting programs. TiVo generates customized listings and automatically records programs, on the basis of the user's choices and explicit feedback, but it also tries to to reason about the user feedback to produce better suggestions. In contrast, Replay records TV events on the sole basis of the user's explicit choices.

5 Conclusions

We have presented the architecture of a prototype system for the generation of personalized EPGs, which are processed and displayed on the users' TV devices. The system, currently under development, runs on the user's Set Top Box and is based on a multi-agent architecture where specialized agents cooperate to the

retrieval of the information about programs and the selection of programs to be proposed, on the basis of the user's interests and watching behavior.

The retrieval of information about programs results from merging the DVB data broadcasted in the satellite stream with information retrieved from the providers' Web sites. In this way, extra-information about programs can be used to improve the suggestion of programs.

The agent-based organization of the architecture supports its flexibility: the system can be seamlessly extended with agents providing new functionalities. Moreover, the execution of activities within the Set Top Box is an innovation with respect to the existing personalized recommender systems and listings services, which require that users connect to central servers offering the related services; e.g., see [4, 6, 14] and [8] for an overview. The decentralization solves important load-balancing issues, as it avoids the management of millions of parallel transactions on a central server. Furthermore, the user's privacy can be protected, as her/his data can be handled locally to the Set Top Box.

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