SOFTWARE AGENTS FOR DIGITAL TELEVISION

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Abstract:

Nowadays more and more audiovisual information is available, from many sources around the world. Computer and data technologies are continuing to develop at a rapid rate, providing higher performance while reducing the cost and size of the system components. Users require assistance to avoid being overwhelmed by this amount of information and the information providers require assistance in authoring and managing it. This large volume of highly dynamic and distributed audiovisual information is an ideal candidate to systems that make use of agent technology. This paper focuses on a specific problem that the audiovisual broadcasting and entertainment industry faces today and how the agent technology will aid in solving it. Intelligent agents, personalization and standards of communication and representation of audiovisual information are discussed. A generic reference model that illustrates the principal concepts and components is presented and some conclusions drawn.

Keywords: Agents, Digital Television, Personalization, FIPA, Reference Model

1 INTRODUCTION

Nowadays more and more audiovisual (AV) information is available, from many sources around the world. According to the findings of a group of faculty members and students at the School of Information Management and Systems at the UC Berkeley [1] the world produces between 1 and 2 exabytes (one exabyte is a 1 billion of gigabytes) of unique information each year, which is roughly 250 megabytes for every man, woman, and child on earth. Printed documents of all kinds comprise only .003% of the total. Audiovisual information plays an important role in our society and much of the bandwidth is taken by this specific type of information. Computer and data technologies are continuing to develop at a rapid rate, providing higher performance while reducing the cost and size of the system components. As prices drop, users will increasingly buy more powerful computer workstations with high-resolution displays and high-capacity magnetic and optical storage components. Audiovisual information will be stored in suitable formats and in digital form, and improved and efficient methods of converting the older materials in non-digital formats are being developed. As the necessary computer networks improve and the merging of data, voice, and video communications over a common network infrastructure is done much of the problems associated with the exchange of audiovisual information will be solved.

With the rise in the popularity of Web photo and video services a large amount of images and videos can be stored online, available for access using large-scale networks (e.g. Internet). As the entertainment, medical and industrial industries join the digital revolution, most of the world's output of photo and video imagery will be online and accessible. However, this rapid proliferation of data has created a monumental problem: How do we swim in this amount of information instead of drowning into it? It is clear that a better understanding and better tools are desperately needed if we are to take advantage of this exponential increase of information (Figure 1-2).

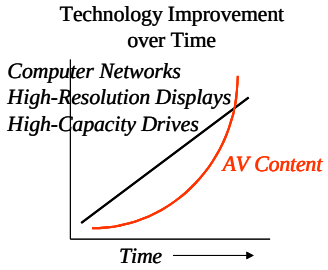

Figure 1 – Technological improvements

Users require assistance to avoid being overwhelmed by this amount of information and the information providers require assistance in authoring and managing it. This large volume of highly dynamic and distributed AV information is an ideal

candidate to systems that make use of agent technology.

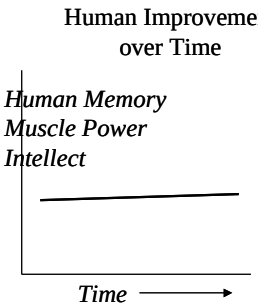

Figure 2 – Technological improvements

These agents will assist the user and the provider as he interacts with the distributed audiovisual information system of the future by [2]:

- ?? Helping the user to discover new sources of AV information.
- ?? Helping the user to navigate the vast amount AV information.
- ?? Helping the provider to author and maintain the AV information.

In this context specialized intelligent systems will be developed to act as our assistants and will have limited but well-defined roles and use artificial intelligence techniques to exhibit behaviour that mimics intelligence. In the context of the computer systems the intelligent agents could perform several actions [3]:

- ?? Monitor databases and capture new and relevant information.
- ?? Filter incoming messages.
- ?? Assist the user in identifying and searching appropriate databases as well as downloading data from these databases.
- ?? Help the user to manage and access personal databases.
- ?? Guide the user in analysing retrieved information using statistical, textual and other analysis tools.
- ?? Help the user to create new intellectual works from retrieved and original information.

The latter four functions could be performed in at least three possible modes:

- ?? Advise mode, where the system monitors the user interaction with the targeted systems, identifies errors, and suggest other possible actions.
- ?? Tutor mode, where the systems teaches the user how the targeted system works by using real or simulated examples.
- ?? Transparent mode, where the system performs the needed interactions with the targeted system in the user's behalf based on his high-level instructions.

The main goal of this work is to study a specific range of applications in the field of software agents: applications that deal with AV information. The software agents are the result of the convergence of different scientific communities: the artificial intelligence, the software engineering and the human-computer interfaces as suggested in [4].

This paper is organized as follows. Section 1 introduces the problem of the overload of audiovisual information and a particularization to a specific type of application: audiovisual broadcasting and entertainment and how the agent technology will aid in tackling this problem. Then, Section 2 discusses how the metaphor of a personal assistant can aid in reducing information and work overload is presented by using solutions developed in the artificial intelligence and human-computer interfaces. The problem of personalization (Section 3), communication and interoperability (Section 4) between different agent systems is discussed and some solutions referred. Finally, a proposal for an agent-based TV service reference model (Section 5) is discussed and the conclusions presented (Section 6).

2 SOFTWARE AGENTS FOR DIGITAL TELEVISION

Digital television is the way that all programmes will be broadcast in the future. Television companies are providing new channels and converting their facilities to take into account the exciting new services that digital broadcasting makes possible. The term '"digital" is used by a wide variety of industries to indicate the use of new functionalities; in technical terms it relates the way that the programmes are processed and transmitted. The digital technology allows for a more efficient transmission and consequently the broadcasting of more TV channels in the same bandwidth of the TV analogue signals. More functionality will be supported since it allows extensive data carrying capabilities that could be used to send useful information associated with the programme being transmitted.

In addition to the above, digital TV brings new services such as widescreen, interactive services, new text channels, sophisticated on screen programme information, email facilities, etc. This increase of the number of available channels, the convergence of TV and Internet, the proliferation of new interactive services will transform the TV box from a program watching device to a portal towards all kinds of audiovisual content and services. Is not far away the day where the viewer will be able to choose between hundreds of television channels (received by cable, satellite or terrestrial networks), or to access video servers to watch any movie at any time (Video on Demand) and consequently have a TV guide the size of a phone book! Traditional manual selection and/or storage of the favourites programs by a viewer will be impossible. In order to cope with the complexity of such an environment and efficiently choose among the huge amount of available alternatives, the users will need an advanced software system to provide them with an intelligent assistant.

One of the most usable agent definition is by Wooldridge and Jennings [5], which discusses agents based on two basic notions: a weak and a strong definition of agents. The strong definition involves artificial intelligence techniques and models to characterize agents using mentalistics notions, such as knowledge, beliefs, intentions and obligations, or even emotional attributes. Based on their tentative agent definition, *the software agent perspective taken into account in this paper focuses on the weak definition for which autonomy, sociability, reactivity and mobility are the most important characteristics*. In this context of digital TV, agent technology will provide an effective way of filtering, accessing and retrieving audiovisual information, particularly for broadcast channel selection. It is also expected to take care of tasks such as profiling and interfacing with the content providers and the users/viewers.

An important requirement of the system to design is the personalization of services interesting to the user and the ability to tailor the available options accordingly to her demands/choices. The core of this personalisation issue is however the development of a user model. User modelling in itself has nothing to do with agents per se, but its full potential surely becomes exploited to a greater extent when used in the pro-active behaviour of the software agent paradigm.

The role of agents in this process shows that we need entities that will assist consumers as well as providers in a business process of electronic audiovisual information. A business process where providers want to advertise and sell their goods to as many buyers as possible in an economically profitable manner; and a process where consumers want to buy goods that match their preferences and needs as closely as possible. This will also allow a new kind of functionality such as the negotiation of the terms of the transaction (e.g. quality of the video requested, bit-rate, cost of the video, time to deliver at the users home, etc). Agent software technology will be able to provide assistance in the conflict resolution of this business process.

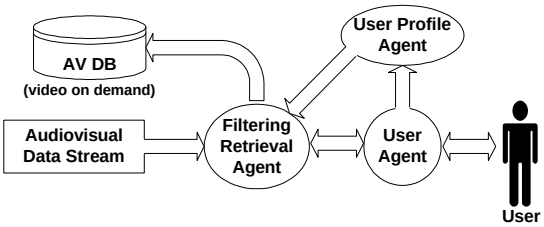

Figure 3 – Overview of the considered application scenario

Figure 3 gives an overview of the application scenario with all elements discussed above present. The *User* should be able to interface with a system with one or more presented agents. The *User Profile Agent* (UPA) should be responsible for creating and maintaining a user profile consisting for example of the user preferences. The *Filtering/Retrieval Agent* should use this user profile in order to restrict the range of results when the User Agent, acting in the user's behalf, makes a query or when the provider announces new services or information. This agent connects to the accessible video databases or audiovisual streams to autonomously retrieve information asked by the user or considered relevant to be presented to the user. The user agent should help the user by means of an easy and intuitive interface, carry out the user orders and help the UPA to construct dynamically a more accurate user profile.

3 PERSONALIZATION

The explosion of new services for the digital television will demand a new style of human-computer interaction to simplify the complexity of this new environment. The computer will become an intelligent, active and personalized collaborator. In order to solve the above stated problem of assistance of consumers and providers, artificial intelligence techniques can be used by the agent involved to acquire competence by learning from the user, as well as from other agents assisting their respective users.

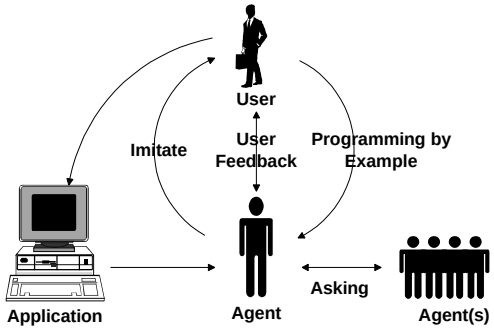

Figure 4 – User/agent training model

The construction of user profile can be made by acquiring information from five different sources of information [6], as exemplified in Figure 4:

?? *Input data* – To construct a user profile is necessary to take into account the input data that the user supplies to the application: the user preferences. For example, a specific kind of programmes (e.g. science-fiction movies); personal data like the age, gender or occupation, technological level; and the characteristics of the terminal used.

?? *User actions* – The agent learns by continuously monitoring the activities performed by the user, keep track of all actions over long periods of time, find common and recurrent patterns and then offer to automate them. For example, if the agent notices that the user always see the news in the CNN channel it can suggest to automate this task the next time the user want to watch the news.

?? *User feedback* – A second source of information that can be used by the agent is the user feedback. This happens when the user neglects or accepts the suggestions made by the agent. The user can also give explicit negative or positive feedback for the actions automated by the agent (e.g. "I don't like this type of programmes" or "I like this film").

?? *Learning from examples* – The agent can also learn from examples given explicitly by the user. The user can train the agent by simulating situations and instructing the agent what to do in those cases. The agent records the actions performed by the user, tracks relationships, and changes his knowledge in order to incorporate the example that is shown. For instance, the user can teach the agent in order to advert the user when a football game between Barcelona and another team is broadcast.

?? *Typical preferences from similar users* – The agent can also ask for advice from agents that assist other users with the same task. These agents may have built more experience and the choices made by other users with the same preferences can be used to suggest new programmes. To accomplish this task a number of stereotypes of users (also known as "user communities") can be built based for example on the static data that the user supplies. The stereotypes and the interaction history can be used to support collaborative reasoning per user and per set of users to get both best match and innovation.

4 COMMUNICATION AND INTEROPERABILITY

Agent technology is currently used to develop products to solve real business problems. However most of the solutions being developed are proprietary solutions, i.e. the agents have a strong relationship between them and use proprietary protocols to meet the requirements of the application. Several groups, such as FIPA (Foundation for Intelligent and Physical Agents consortium) or OMG (Object Management Group), recognize the need for *technologies and interoperability specifications that facilitate the end-to-end interworking of intelligent agent systems in modern commercial and industrial settings* [7].

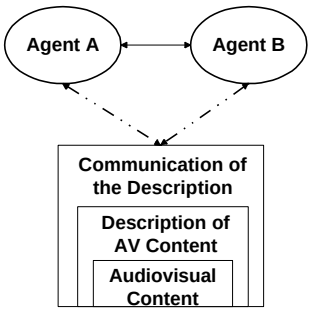

Figure 5 – Three levels of information sharing in the agent communication process

In the inter-agent communication process there are three essential levels involved as depicted in Figure 4. The first one is the *information* itself, in this case is audiovisual content (e.g videos, images, 3D models); the second one is a language or protocol that specify the *representation of the information*,

i.e. a description of the audiovisual information; and the third is a language or protocol that specifies how the *communication of this descriptions of audiovisual information* is made.

4.1 Representation of AV Information

A ISO standard is introduced that could be used to achieve a common representation of audiovisual content between all the participants in the process. In 1996 MPEG has recognized the need to identify multimedia content, and started a working item formally called 'Multimedia Content Description Interface', better known as MPEG-7 [8]. The new MPEG-7 standard will provide a rich set of standardised tools to describe multimedia content (i.e. speech, audio, video, still pictures and 3D models). It will standardize:

- ?? A set of descriptors (Ds)
- ?? A set of description schemes (DSs)
- ?? A language to specify description schemes (and possibly descriptors), the Description Definition Language (DDL)
- ?? One or more ways to encode descriptions

The specification of MPEG-7 standard concern five main parts, namely:

- ?? *MPEG-7 Systems*, that deal with the efficient transport and storage of descriptions
- ?? *MPEG-7 Description Definition Language*, the language for defining new DSs and new Ds
- ?? *MEG-7 Audio*, the Ds and DSs dealing with (only) audio descriptions
- ?? *MPEG-7 Visual*, the Ds and DSs dealing with (only) visual descriptions
- ?? *MPEG-7 Generic Entities and Multimedia Description Schemes* (MDSs), the Ds and DSs dealing with generic features and multimedia descriptions.

The description tools of the last part of the standard [9] allow the representation of perceivable information about the content (semantic information associated to an audiovisual document). This part also contains a set of descriptors related to the management of the content; essentially about the creation of the content, the description of the media (e.g. format, type of compression) and metadata information that cannot be automatically extracted (e.g. the producer of a film). This kind of information is very useful in order to implement the search/filtering functionality. Possible queries to the system are: "find me a channel with news about the election of USA" or "list all channels where films made by Steven Spielberg will broadcast". Also the description of a piece of content with a set of meaningful words allows the filtering of the programmes being transmitted or stored accordingly to a set of preferences constructed by the user or by an agent that monitors the user actions and constructs a user model.

4.2 Inter-Agent Communication

Now that a common representation of the audiovisual content was presented is also needed a common language for agent communication between different platforms. The FIPA consortium was formed in 1996 to produce software standards for heterogeneous and interacting agents and agent-based systems. FIPA proposes a set of standards that provide [10]:

- ?? A commonly agreed way which agents can communicate in order to exchange information, negotiate for services, or delegate tasks.
- ?? Functionalities for agent localization (i.e. directory services) and agent identification (i.e. globally unique names).
- ?? A secure environment for execution of agents and exchange of confidential information.
- ?? A means of accessing systems and interacting with users.
- ?? Functionalities for agent migration between platforms, if necessary.

The adoption of such a standard is a prerequisite to the large-scale commercialisation and successful exploitation of a system that tries to solve the problem faced by the entertainment industry today.

5 REFERENCE MODEL

Considering that this field of research is relatively recent, and deals with different scientific communities with different perspectives, is necessary the definition of a reference model that illustrates the principal concepts and components. This reference model is sufficiently generic to be used by different agent systems. The reference model proposed has three main components as show in the Figure 6: the user domain, the broker domain and the provider domain (see below for more details). Not all the components involved in this model have to be implemented in order to the system fulfil the requirements. For instance, if the profiling

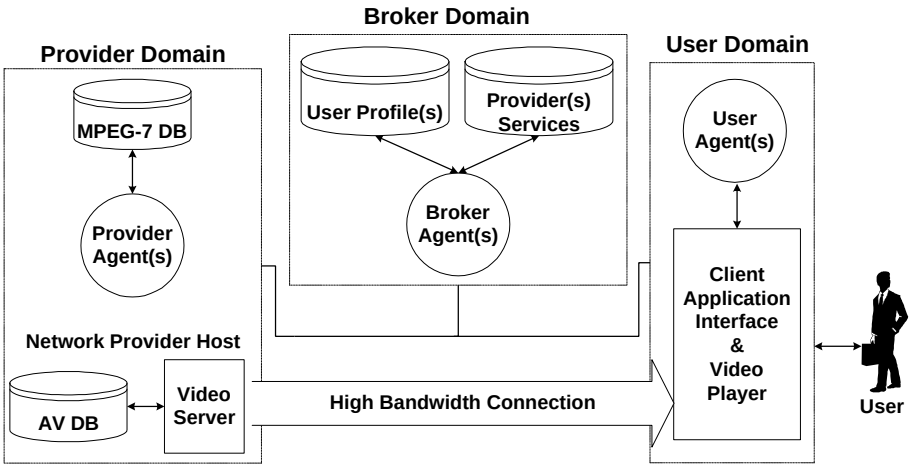

Figure 6 – Front end interaction reference model

of the user is neglected, the Broker Domain can be suppressed with obvious consequences on the interaction between the system and the user.

Although is not depicted in this reference model, one component needed is the agent platform itself, because such infrastructure is mandatory to allow agents to act in a multi-agent environment with several attributes, such as: execution, management of agent types, management of identifiers, persistence, navigation, communication, interaction with external resources and security. The discussions of these basic agent infrastructure needs are out of the scope of this paper. The interested reader can consult the reference [11] for a deeper discussion on these issues.

In a commercial system distinct companies should offer the services of the provider domain, network provider host and broker domain. In those contexts, with heterogeneous agents systems, the importance of satisfying standards like FIPA and MPEG-7 is vital.

5.1 User Domain

The user domain hosts one or more agents responsible by the interaction between the user and the system; a client application interface; and a video player to watch the audiovisual content. Optionally a video recorder can be present in order for the user record programmes in a manual or autonomous way.

The user domain should allow the user to register with the audiovisual and broadcasting system, input his personal data and static preferences. It should also provide a way for visualization of a personalized list of suggested programs or movies. The user will be able to delegate tasks to the user agent(s) such as search for a specific type of audiovisual content. For example suppose that the user's football idol is "Luis Figo". To retrieve any sports program or movie with the player the user must make a query to the user agent or client application interface and the user agents must show all results filtered according to the user profile and viewing time specified by the user (e.g., if the program is available now or at a later time).

5.2 Broker Domain

The human interaction in this domain should be implemented with care and advanced forms of user interfaces must be studied because with intuitive and personalized interfaces the user will feel more comfortable in delegating tasks to an agent. The use of multi-modal agent interaction system should be considered by applying a mixture of technologies: voice recognition, language dialogue systems, animated characters with affective traits. An application with these new technologies was developed by the FACTS project and presented in [12].

The broker domain act as an intermediary service between users and providers and tailors the programme guide to each specific user or stereotype of users (i.e., user communities). In the broker domain the broker agent(s) act as the manager of the personalization service, and the user(s) profile and provider(s) services. The intermediary is also the owner of the user agent(s), which are distributed to the users after their subscription with the service.

The broker agent(s) are responsible for several tasks, namely: (1) the maintenance of a user profile, consisting of personal data and dynamic users preferences; (2) the search, retrieval and filtering of

information based on the user profile; and (3) registration of services by the provider and user agents by the users. Is also responsible for the communication and negotiation between end users and providers, represents all users or a set of users from the provider viewpoint and represents all providers from the user viewpoint.

In the reference model proposed, the broker domain is the critical point where performance and scalability can be handled through the adoption of concurrent flows of execution within a single agent or agent farm models. For instance, a hierarchy of agents or a mixed model should be used to speed up the operations of search and retrieval of the TV programmes or movies.

5.3 Provider Domain

The provider domain host the provider agent(s) that are able to explore the MPEG-7 database via the formulation of queries. Maintains a database consisting of descriptions of audiovisual material to be broadcast and an agent or a dynamic set of agents responsible for the communication of the exploration results to agents outside the domain. The provider must implement its provider agent(s) and register the services to offer with the intermediary (responsible for the broker agent(s)). An alternative is the intermediary service supplies a default piece of software to be configured by the provider. The decision depends on the importance of the service provider and of the complexity of services that are proposed. Another component of the provider domain is the network provider host, which is responsible for the broadcasting and deliverance of an audiovisual broadcast stream for the end users. The successful MPEG-2 standard can be used to accomplish this task.

5.4 Examples

In the DICEMAN (**D**istributed **I**nternet **C**ontent **E**xchange and **M**ultimedia **A**gent **N**egotiation) ACTS project [13] the only functionality needed is the selection and retrieval of multimedia information of interest to the user in the Internet; so, the user agents communicate directly with the provider agents. An elaborate client application interface was designed in order to provide the construction of queries by the user. The scenario of the application is a pull scenario where audiovisual resources (in the MPEG-7 format) are numerous and distributed in the Internet and users will use agents to delegate their search.

The FACTS (**F**IPA **A**gent **C**ommunication and **T**echnologies) ACTS project [14] primary objective is to validate the work of FIPA by the construction of demonstrator systems in three application areas. One of these areas is the audiovisual broadcasting and entertainment [12][16] where a prototype was developed to test the problem of agent interoperability. In this project the Client Application Interface was incorporated in the User Agent(s) by the construction of a User Interface Agent (manages a set of Java frames), a character agent (to reason about information in an affective manner) and a natural language agent (to establish a better and more natural interface between user and agent worlds). In FACTS the Broker Domain consists of several agents that manage the provider services and user profiles. One drawback of this project is the use of proprietary implemented EPG (Electronic Programme Guide) instead of a standardized description of the programmes being broadcasted (for example MPEG-7).

6 CONCLUSION

New and exciting technologies are emerging that allow the birth of new ways of communication and interaction [17]. However, these technologies and business scenarios are not yet completely understood and fully imagined. The linking of these new technologies will be able to fit your own personal needs instead of the old TV broadcast to million of viewers.

The technologies will challenge the user with multiple levels of interaction to give you with the best high-definition, multi-channel entertainment you want to have; it will be indexed and easy to explore or just surprise you with things that you would never expected.

Agent technology will ease tasks such as profiling, filtering and interfacing. It will also make new functionality such as negotiation of the quality of service (e.g. cost, urgency, bit-rate), brokering and trading of user-preferred programmes to be delivered.

This paper describes the technology needed to develop and demonstrate the interaction between an end-user and a multi-agent system. The overall functionality of this technology is to allow users to select and retrieve audiovisual information of interest in a friendly way. Intelligent agents, personalization and standards of communication should help to build these business scenarios in a near future.

ACKNOWLEDGMENTS

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