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AN ARCHITECTURE FOR VIDEO ON DEMAND AGENT-MEDIATED ELETRONIC COMMERCE

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Abstract

We explore the requirements and issues related to video on demand electronic commerce using agents as mediators in the customer-to-business and business-to-business relations and propose an architecture for multi-agent systems acting on a wide range of situations. Agent technology is suitable since video-on-demand is a personalized service by nature. The agents' roles are examined in the context of a Consumer Buying Behavior (CBB) model.

1. Introduction

A Video on Demand system (VoD) is a distributed multimedia application that allows a user, through a remote terminal (e.g. a television and a set-top box), to access a video catalog composed of videos stored in several servers distributed in a network.

Since the customer has total freedom in choosing which video program he/she will watch and also in which interaction level (broadcast, NVod, QVod, TVod [13]), this class of systems has an enormous potential of marketing application and some prototypes have been developed, particularly in the areas of education and entertainment. Several researches have accomplishments in the area; however, most approaches are related to aspects of communication, storage and location of the multimedia information, that is, the focus is the technological point of view, willing to obtain great performance of storage means and communication channels [19, 20]. Otherwise, very few projects have addressed points regarding the abstract modeling of this class of systems [15]. Those studies became extremely desirable, especially when one wants to build VoD applications of larger complexity as, for example, virtual libraries and distance learning environments.

Video-on-demand systems, like other information systems (such as on-line bookstores and music distribution networks) need to implement efficient forms of presentation to show alternative options to its customer, due to its great amount of information and also great complexity trading scenarios. The majority of the present VoD applications provide interfaces which are similar to static mail-order catalogs. Software agents can be used to automate a variety of tasks, including buying and selling products, such as movies, books, CDs and other forms of entertainment [1]. In this scenario, agents might play important roles in filtering and retrieval, personalized evaluation and decision making. Agent technology is applied where the continuously-running, semi-autonomous and personalized nature of agents can be explored [2].

We explore the requirements and issues related to VoD electronic commerce using agents as mediators in the customer-to-business and business-to-business relations and propose an architecture for multi-agent systems acting on a wide range of situations on the VoD scenario. The agents' roles are examined in the context of a Consumer Buying Behavior (CBB) model presented in [3].

Both the environment of e-commerce and VoD applications are information-rich and process-rich, making agent technology more suitable to meet both the user and provider expectations.

The next sections are organized as follows: Section 2 shows an overview in the VoD domain both in its concepts (2.1) and the relations among them (2.2);

Section 3 describes the VoD architecture; Section 4 present the agent-augmented archicteture and explore the agent-roles based on the CBB model. Section 5 explore issues on privacy and trust in the agent system. Finally, Section 6 presents conclusions and perspectives.

2. Video on Demand domain overview

This work borrows the logical architecture of a VoD system called Hipervisão [18]. The system goal is to create a interdisciplinary structure connecting several academic departments, possibly of several institutions in different countries, in order to offer to its final users (students) digitalized classes and educational videos.

The system was developed using a reuse-oriented system engineering process called LogicOO[17]. This methodology introduces a domain analysis and specification phase [16] in which the domain knowledge (instead of application knowledge) will be formalized in the highest level of abstraction using ontologies[1]. This approach leads to a reuse maximization: a domain ontology can be specialized in several different applications directions (different system requirement models for different purposes).

Likewise, in this case, first, a video on demand domain ontology was constructed, then a conceptual architecture was conceived, and finally this architecture was specialized in a VoD application. Figure 1 bellow shows the main concepts (and the relations among them)

[1] Ontology is term ontology borrowed from Philosophy and means *"a specification of a conceptualization"*. However, in a more pragmatical reading it is a formal description of concepts and relationships that can exist in specific area of interest [21].

involved in the VoD generic domain. They are presented here as introduction to the VoD domain. In this diagram, the rectangles represent the concepts while the arrows tying the rectangles represents the relations among them.

In a first analysis, five concepts can be identified: S(servers), T(terminals), V(videos), P(providers) and E(exchanges). These concepts works as classes, representing the behavior of the concepts instances in a class/instance relation very much like in object-oriented paradigms. Likewise, when we refer to a private particular server s1, we are referring to an instance of the concept (class) S.

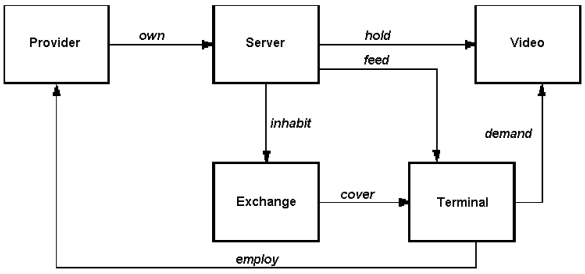

Figure 1 - Initial Concepts/Relations Diagram for the video on demand domain

In the Hipervisão domain model, according to the LogicOO methodology, the axioms formalizing all the cardinality and relation constraints involving these elements are described using a phrase notation which is omitted due to the scope of this paper.

2.1 - Concepts descriptions

Terminals: offers the two main functionalities of a VoD system in the user's point of view: *navigation and control*. Navigation is whole process that begins when the user login the system and ends when the video exhibition session is initiated. It is divided in sub-processes, that are: login/logout, selection of the programming, verification of attended films, verification of bills and video formatting. In this last one the user should be enabled to choose the format of the video to be attended, as original sound, language, subtitles, QoS parameters and even the amount of commercial attended can be modified in agreement with the user's preferences. The control consists of receiving, decoding and executing the video playback. For this second functionality the terminal is also responsible to send user's interaction commands to the server its communication with. The terminal receives the video through a connection between it and the server and interact with it providing to the user a virtual VCR service (pause, FF, rewind, stop, play, sound control, mute control).

Servers: stores and transmits the video material to the terminals. They also have the function of responding to the commands of interaction of several terminals simultaneously. They supply necessary instructions for the execution of the management functions, controlling the users access, providing the navigation service, executing functions of commercial management and controlling sessions.

Videos: They are probably the main actors in this domain. Videos include characteristics as: main actors, director, duration, soundtrack, genre of the film, original sound or dubbed, subtitles, etc. These characteristics are helpful to guide the user in the video choice, allowing him/her to make searches for videos titles involving these attributes (e.g. searching for director, or actor).

Providers: The Provider is an entity that owns servers and it is hired by terminals, being responsible for maintaining the video catalogs in its servers, besides taking care of tasks as marketing and billing the offered service.

Exchanges: It can be a local phone exchange, a CATV Headend or yet a local area network (LAN) in the educational scenario. This entity plays a delimiting role for of a group of Terminals and Servers. This is the first object that appears due to the necessary technological requirements for the offer of the service. This concept is necessary to the formal definition of relation "feed", meaning, without it would be hard to demonstrate that in realistic domain it is not true that any Server can feed any Terminal.

2.2–Relations descriptions

The four relations below have important characteristics that should be highlighted:

Server inhabits Exchange: it emphasizes the presence that should exist of the Server in the Exchange that covers the Terminal that the Server feeds.

Exchange covers Terminal: with the "Servers inhabit(s) Exchange" relation, it composes a ternary relation among these entities. A Server can only feed a Terminal if there is an Exchange inhabited by this server that covers that Terminal.

Server feeds Terminal: it is a bi-directional communication that should exist between both so that the interactive exhibition of the videos can happen. This relation encapsulates a group of logical restrictions that must be satisfied so that a terminal can be fed by a server.

Terminal demands Video**:** A terminal can only demand a video that belongs to its video catalog, in other words, a video that belongs to a provider hired by this terminal.

3. The Video on Demand Ontology specialization

Following the LogicOO methodology, once the domain ontology is built, the next phase is to conceive a conceptual (logical) architecture and incrementally specialize it towards the application desired scenario. Figure 2 shows a brief form of such a architecture. In this prototype, due to its educational purposes, the Local Domain Networks (LDN) are departmental TCP/IP LANs, the Remote Access Network (RAN) is the Internet and the end-user's terminals are PC’s running a Java video system implementation. But since the conceptual architecture maps all the constraints formalized in the domain level, the basic elements of this scenario (LDN, RAN, terminals, providers) can be switched by other elements, providing that the functional and relational characteristics are maintained. Therefore, other implementations (meeting other application requirements, e.g. a commercial scenario) could be considered without loosing the already mentioned logical mapped constraints (e.g. ADSL links grouping set-top boxes terminals linked by an ATM network).

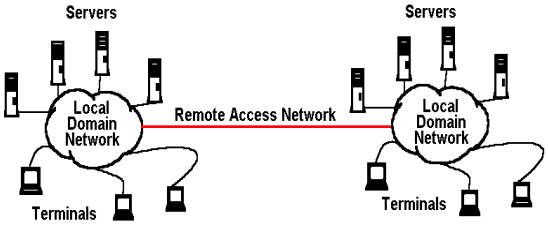

Figure 2 – video on demand conceptual architecture

The system is divided in three main subsystems: AMS (Application Management System), VoDS (Video on Demand Server) and EUT (End-User Terminal). These subsystems are organized in a two-layer model, willing to raise the system's modularity and therefore reach a steadier structure in which different pieces of functionality are delegated to different subsystems. The AMS exists in **management layer**, the VoDS in **system layer** and the EUT in both of them.

The management layer, materialized by the AMS, is responsible for dealing with four actors: system, marketing and provider administrators (through the *operation* use-case) and the end-user, which is the main actor of the system, through the *navigation* use-case. The set of services offered by this layer is constituted by: user's authentication handling and login validation, video selection, user's account consults, provider and servers catalog maintenance, user modeling and so on.

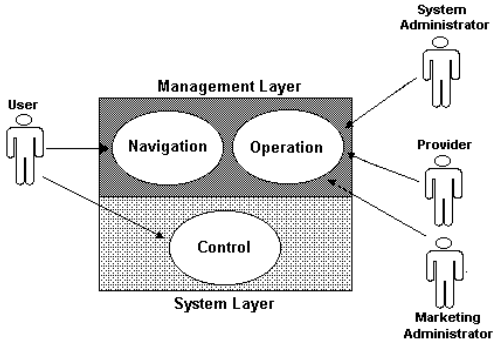

Figure 3 - actors and uses cases in the system

The system layer otherwise is responsible for video storage, transmission and synchronized playback, besides the user interaction handling. This is accomplished by the client (EUT)/server(VoDS) interaction through a multimedia framework composed of network, transport, synchronization and specification functionalities. More information about the several layers, systems and services in the Hipervisão prototype, among with a implementation-oriented discussion can be found in [18].

4. The Multi-Agent System Architecture

Due to this article approach, we focus on the management layer. The management layer is controlled by a entity named AMS (Application Management System) [15] whose two main purposes are: first, to offer the user the management functionality already mentioned, and last, to mediate the communication and also the trading activities in both a customer-to-business base (terminal-AMS) representing providers' issues and customers' interests and in a business-to-business base (AMS-provider and AMS-AMS).

The Multi-Agent System VoD architecture and the market relations considered can be seen in the diagram bellow:

A Consumer Buying Behavior (CBB) model, presented by Guttman et al. which augments traditional marketing research is used to analyze consumers' actions in electronic markets [3] and identify agents' roles. Six stages in shopping experience are considered:

1. *Need Identification* - the consumer realizes some unmet need
2. *Product Brokering* - information is retrieved so as to evaluate *what* to buy
3. *Merchant Brokering* - merchant-specific information used to determine *who* to buy from,
4. *Negotiation* - prices and other aspects of the commercial deal are determined
5. *Purchase and Delivery*
6. *Service and Evaluation* - post-purchase stage: evaluation of satisfaction.

The purpose of the multi-agent system is to strengthen the relationship between customer and supplier exploring the CBB stages. Long-term relationships with customers to maximize customer satisfaction are desired.

It is important to notice that the boundaries between the stages are not necessarily well defined and this model is an approximation of complex behaviors. We will see specifically in the proposed multi-agent system that the product brokering and merchant brokering might be promoted simultaneously.

Following this approach, the AMS can delegate its tasks to an agent community that will interact to accomplish the AMS's objectives. The agents are:

- *Notification Agents*
- *Recommendation Agents*
- *Broker Agents*
- *Movie Reputation Agents*
- *Personal Agents* (are located on customer terminals)
- *Provider Agents* (interact with the system layer in providers)

Figure 8 shows a view of the architecture where the agents are bound to specific AMS. In fact, *Notification, Recommendation* and *Movie Reputation Agents* might be AMS-independent. That must not be neglected, once these entities are usually independent such as movie rating and parental guidance organizations.

4.1 Notification Agents

In the proposed architecture *Notification Agents* area responsible for anticipating customers' needs through the suggestion of new products which are likely to be of their interest. The Need Identification buying stage is addressed.

This is accomplished by the use of a knowledge base with customer data (user profile) shared with the *Recommendation Agents*. Mechanisms of social or

automated collaborative filtering are used to identify "like-minded" people extracting correlation between user profiles as explored in [6], and implemented in Firefly [11] and Movie Critic [12]. Other approaches for speculating on users' interests include genetic algorithms, neural networks [7] and content based filtering [9].

Social filtering mechanisms are suitable to explore feedback from many users to generate predictions to a specific user. Statistical correlations are calculated comparing the profile of the user to the profiles of other users, weighing them according to their level of similarity. These mechanisms overcome the limitation of content-based filtering where the items must be of parsable form (hence excluding video). Besides that, movie filtering must handle quality, style or point-of-view, an absent concern in content-based filtering [6].

In the VoD scenario *Notification Agents* are entitled to propose richer forms of notification to *Personal Agents*, such as: movie trailers, making-offs and movie reviews, i.e., advertising on video as opposed to e-mail text-only alerts. These notifications explore the autonomous nature of agents.

Concerning AMS-AMS relations, Need Identification is explored by having *Notification Agents* trying to sell their products to other *Broker Agents*. Customers' requests for specific videos not listing identify possible AMS-AMS relations.

4.2 Recommendation Agents

Recommendation Agents are responsible for the Product Brokering stage. They share the knowledge base with the *Notification Agents*. Their goal is the reduction of consumers' search costs and therefore the transactions costs [8]. *Recommendation Agents* should satisfy more complex requests than those handled by usual catalog systems.

Communication with *Personal Agents* includes proactive program suggestions, hard-constrained program recommendation (director, language, genre, casting, release date, etc.), group program suggestions, customer rating prediction on specific videos, etc.. All recommendations are accompanied by probable customer rating, like-minded people reviews, confidence level, average rating, traditional reviews and general information about the movie. Traditional catalog functions are also in the AMS. These are static catalogs, with keyword and hard-constrained search.

Personal Agents provide rating and reviews on programs already seen, and suggest new programs for the catalog, helping to build the user profile. Especially, the social filtering mechanism enable customers to combine and share experiences either indirectly (through "like-minded" approach) or directly (through written program reviews).

Statistics are typically useful for System/Marketing Managers, generating dossiers on programs and popularity statistics (top/bottom-rated movies).

4.3 Broker and Provider Agents

On behalf of the customer, the AMS Broker Agent will consider different options supplied by the Providers.

Products offerings might be compared within a specific provider (merchant) or across provider boundaries (cross-merchant). Within-Merchant product comparisons, are usually promoted by users browsing a specific web site.

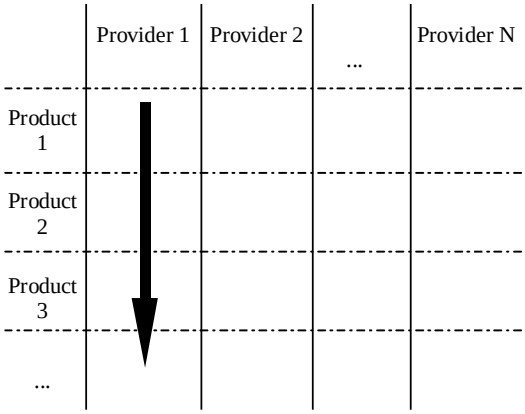

Figure 5 - Within-provider comparisons

Non-mediated cross-provider comparisons would demand extra effort by the customer, visiting several web sites and browsing catalogs.

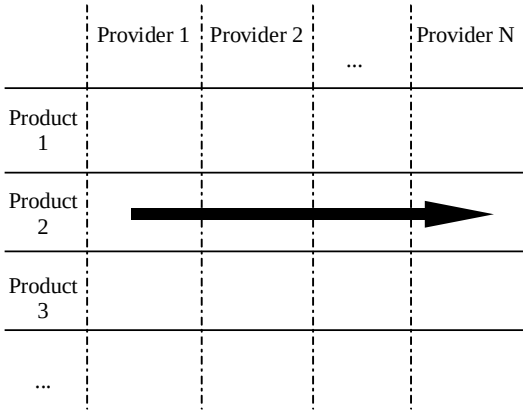

Figure 6 - Cross-provider comparisons

To preserve *merchant differentiation* price-only comparison is avoided and *value-added services* are considered in the buying decision [5].

Some *value-added services* in the VoD domain are:

- QoS parameters
- Interactivity levels
- Advertising levels
- Customer service and support, return policies, promotions and coupons
- Provider personal preference and reputation.

These services distinguish different providers and are critical to one's buying decision: *value-added services* are known to modify completely the VoD customer experience. For instance, there are users who will accept to watch their favorite movies on delayed broadcast and others who would rather pay extra to have full video on demand sessions. Other services might become of interest to the negotiation phase, given the popularization and future market differentiation.

Cooperative rather than competitive negotiation allow agents to negotiate over multiple dimensions, using Multi-Attribute Utility Theory and Distributed Constraint Satisfaction. It is known that auctions and other forms of competitive negotiation are generally "win-loose" relations [10].

As noted in [3], the CBB model is an approximation of complex behaviors. The Product Broker stage might not be finished yet and the Broker Agent might select *what* to buy and *who* to buy from simultaneously in what we will call *cross-merchant multiple-products comparison*. This augments the comparison strategies considered by [5].

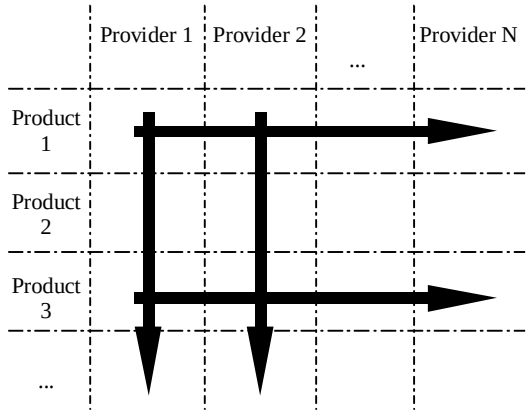

Figure 7 - Cross-provider multiple products comparisons

The definition of *how* to buy, i.e., the *value-added services* should also be of concern in the negotiation. Price of delivery in other electronic commerce systems are substituted by network and server resource charges. Notably, full video on demand sessions are more expensive than delayed broadcast.

4.4 Purchase and Delivery

The final product of a video-on-demand session is a set of video programs. More than that, the result of the electronic commerce negotiation phase is a set of video programs associated with video playback parameters. These programs are to be viewed by the customer.

For that, the delivery of products is handled by the Broker Agent, and its interface with the system layer. As we have already stated, the system layer is responsible for video storage, transmission and synchronized playback and user interaction handling. Further information and an implementation-oriented discussion about the system layer can be found in [17].

4.5 Service and Evaluation

This post-purchase stage is characterized by the evaluation of satisfaction.

The functioning of the Need Identification, Product Brokering and Merchant Brokering is quite influenced by the feedback provided from the user at this stage. The customer might rate or review the program, adding important data to the system as a whole.

Agents acting at this stage play an important role in the Need Identification for products there are likely to be consumed after the video session. Impulse buying should be explored initiating new purchasing processes.

Privacy and Trust

Competence develops over time, as the number of user profiles used to generate predictions increase [6].

As long-term satisfaction is aimed, the evaluation performed by Recommendation and Notification Agents should be trustworthy and reliable, even alerting users of movies they will dislike. We try to achieve "win-win" relationships.

The agents must be able to explain their decisions, and exhibit predictable behaviors to increase users' trust [2].

Customers' data policies should be clearly stated, since privacy is of great users' concern. Lack of users knowledge of the mechanisms being used to share their preferences and historical data might lead to mistrust. It is so unlikely that under this situation users will allow the system to track their decisions, preventing us from obtaining feedback to our social filtering mechanisms. Lack of user feedback due to mistrust will restrict the work in the early stages: Need Identification and Product Brokering. The user must be notified that the whole process consider his/her profile from an anonymous point-of-view and specific data about him/her will remain private.

Conclusion and Perspectives

The one-to-one marketing becomes closer to reality in VoD agent-mediated systems since VoD systems are personalized by nature. The architecture discussed might be applied to other entertainment industries such as music, books and generalized to media-on-demand services. The analysis of the system based on a consumer buying behavior model helps us to understand the system's interaction with the end user.

Recommendation Agents will profit considerably from advances in natural language queries and video and audio recognition and semantics extraction. Automatic attribute information extraction in content-based filtering algorithms for video will allow consumers to specify other objective properties, with hybrid social and content information filtering. Concepts that have a specific meaning in a specific domain might be inferred from the color, shape, and motion of objects present in the video. (e.g. "I would like to see that movie in which Charles Chaplin is shown as a labor", or "A scene with a soccer game"). Besides that, clustering techniques to identify emergent program "genres" or "types" might be used in the prediction algorithms.

Personal agents can be extended to participate more actively in the process of *Need Identification*, anticipating predictable consumer behavior, such as habits.

Agent technology as a whole will benefit from the definition of common agent languages and protocols. Agent-mediated e-commerce applications will have major advances when standards for defining products, value added services, consumer profiles, payment mechanisms, etc. are established.

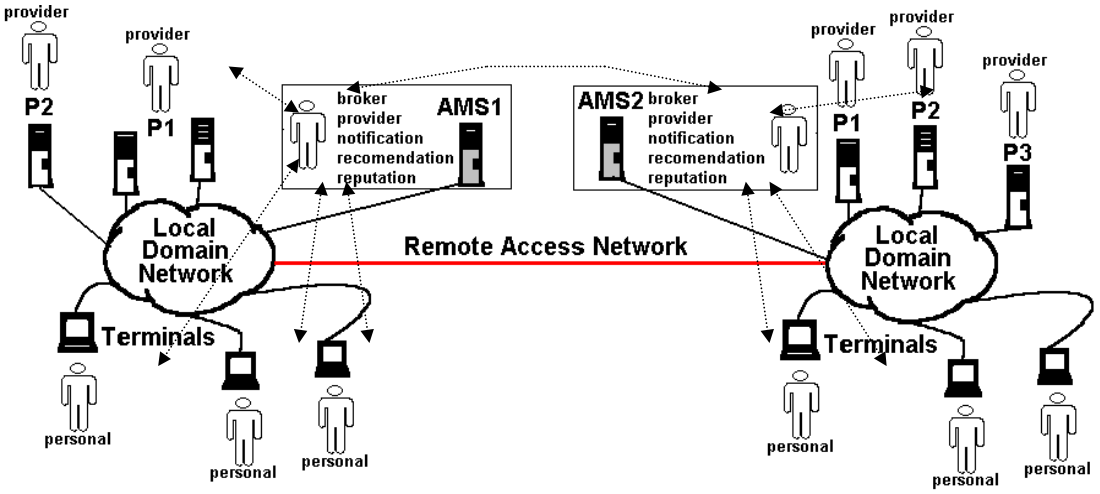

Figure 8 – multi agent system augmented VoD conceptual architecture

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