A CASE STUDY ON THE APPLICATION OF THE MAAEM METHODOLOGY FOR THE SPECIFICATION MODELING OF RECOMMENDER SYSTEMS IN THE LEGAL DOMAIN

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Abstract: Recommender systems have been target of continuous research over the last years, being used as an approach to the information overload problem. The Semantic Web is a new generation of the Web which aims at improving the effectiveness of information access on the Web by structuring its content in a machine readable way. Agents have been also object of active research on the software engineering field considering the high level of abstraction for software development provided by the multi-agent paradigm. This paper describes the modeling of Infonorma, a multi-agent recommender system for the legal domain developed under the guidelines of MAAEM, a methodology for multi-agent application development, which is also evaluated here.

1 INTRODUCTION

Recommender systems (Adomavicius and Tuzhilin, 2005) (Ziegler, 2004) are a particular type of filtering applications. They help users to deal with the problem of information overload. In content-based approaches (Adomavicius and Tuzhilin, 2005) (Balabanovic and Shoham, 1997) they provide the users with recommendations of items that are similar to the ones that they preferred in the past. This is achieved by measuring the similarity between information items representation and user profiles.

Most of the content-based filtering algorithms use statistical-based methods to measure similarity between user models and information item representations (Adomavicius and Tuzhilin, 2005). Those methods do not consider any kind of semantic processing, which is the reason why ambiguity problems are faced by content-based filtering systems.

The Semantic Web (Antoniou and Van Harmelen, 2004) is a new generation of the Web in which data is structured in such a way that it can be machine readable and exhibited in a user-friendly way. This is done with the use of ontologies (Gruber, 1995) and standard technologies defined by the World Wide Web Consortium (W3C). With a semantically structured representation of Web data, recommender systems can use semantic-based similarity measures in order to improve their effectiveness.

Agent-oriented Software Engineering approaches the increasing complexity of computing systems that must operate in open and quickly changing environments by improving our ability to model, design and implement complex systems (Jennings, 2000).

MAAEM ("Multi-agent Application Engineering Methodology") (Lindoso and Girardi 2006) is a software development methodology for multi-agent application engineering based on the reuse of software artifacts developed in a Domain Engineering process guided by the MADEM ("Multi-agent Domain Engineering Methodology") methodology (Girardi and Marinho, 2007).

Infonorma (Drumond, Girardi, Lindoso and Marinho, 2006) is a multi-agent recommender system for the legal domain that recommends legal normative instruments to users according to their particular interests. The information items of Infonorma are represented as instances of the ONTOJURIS ontology, which is written in OWL according to the W3C recommendations. The system was modelled under the guidelines of the MAAEM methodology and this experience has contributed for its evaluation.

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This paper focuses on the requirements specification of Infonorma and the Application Analysis phase of the MAAEM methodology. The description of the architectural and detailed design as well as the implementation of Infonorma is not provided here due to space restrictions.

This paper is organized as follows. Section 2 introduces the main modeling concepts of MAAEM and briefly describes its tasks and products in the context of a multi-agent application engineering process. Section 3 provides an overview of the system specification, describing the tasks carried out and their respective products. Section 4 analyzes related work on multi-agent and Semantic Web recommender systems. Finally, Section 5 concludes this paper with some remarks on further work being conducted.

2 AN OVERVIEW OF THE MAAEM METHODOLOGY

Multi-agent Application Engineering (MaAE) (Jennings, 2000) is a process for the development of specific applications through the reuse of software artifacts produced in Multi-agent Domain Engineering (MaDE) (Girardi and Marinho, 2007), a complementary and interdependent process. MAAEM is a methodology for analysis, design and implementation of multi-agent applications through the reuse of software artifacts such as domain models, multi-agent frameworks, pattern systems and software agents. MAAEM also supports the development of applications from scratch, without reuse, as is the case of the development of Infonorma.

The ONTORMAS ("ONTOlogy driven tool for the Reuse of Multi-Agent Software") ontology works as a modeling tool and a storage repository for products constructed on the Multi-agent Domain Engineering and Multi-agent Application Engineering processes. MAAEM products are represented as instances of ONTORMAS ontology.

For the specification of an application, MAAEM focuses on modeling goals, roles, activities and interactions of entities of an organization. Entities have knowledge and use it to exhibit autonomous behavior. An organization is composed of entities with general and specific goals that establish what the organization intends to reach. The achievement of specific goals allows reaching the general goal of the organization. Specific goals are reached through the performance of responsibilities that entities have by playing roles with a certain degree of autonomy.

Entities playing roles have skills on one or a set of techniques that support the execution of responsibilities in an effective way. Pre-conditions and post-conditions may need to be satisfied for/after the execution of an activity. Knowledge can be consumed and produced through the execution of an activity.

For the specification of a design solution, roles are assigned to agents structured and organized into a particular multi-agent architectural solution according to non-functional requirements.

Table 1 summarizes modeling phases, respective tasks and modeling products of MAAEM.

Application analysis is performed through the following modeling tasks: concept modeling, goal modeling, role modeling and role interaction modeling. An Application Specification is the product of this phase and it is composed of each one of these task products: concept model, goal model, role model and role interactions model, respectively.

The concept modeling task aims at performing a brainstorming of concepts involved in the application and their relationships, representing them in a concept model. These concepts can also be selected for reuse from a domain model, if one is available. This starts from an informal analysis of the application requirements. These concepts are refined in the subsequent modeling tasks.

Table 1: Modeling phases, tasks and products of MAAEM methodology.

Phases		Tasks	Products	
Application Analysis		Concept Modeling	Concept Model	Application Specification
		Goal Modeling	Goal Model	
		Role Modeling	Role Model	
		Role Interactions Modeling	Role Interactions Model	
		User Interface Prototyping	User Interface Prototypes	
Application Design	Multi-agent Society Knowledge Modeling		Multi-agent Society Knowledge Model	Application Architecture
	Architectural Design	Multi-agent Society Modeling	Multi-agent Society Model	Architectural Model
		Agent Interaction Modeling	Agent Interaction Model	
		Coordination and Cooperation Mechanisms Modeling	Coordination and Cooperation Mechanisms Model	
	Agent Design	Agent Knowledge and Activity Modeling	Agent Knowledge and Activity Model	Agent Model
		Agent State Modeling	Agent State Model	
Application Implementation		Mapping from design to Implementation Agents and from Responsibilities to Behaviors	Model of Agents and Behaviors	Application Implementation Model
		Mapping of Agents Interaction and Communication Acts	Model of Agent Communicative Acts	

The purpose of the goal modeling task is to identify the goals of the system, the external entities which it cooperates with and the responsibilities needed to achieve them.

In the role modeling task, the responsibilities identified in the goal model, are assigned to roles as well as the used and produced knowledge, imposed pre-conditions, post-conditions and required skills.

Once the roles present in the application are selected, adapted and composed, it is needed to establish how the internal entities playing the roles interact with each other and with external entities, which is done in the role interactions modeling task. The product of this task is a set of role interaction models, one for each specific goal.

The user interface prototyping task is developed in parallel with the goal modeling, role modeling and the role interactions modeling tasks. Its product is a set of user interface prototypes.

The design phase, supported by the ADEMAS technique, approaches the architectural and detailed design, defining a solution to the requirements specified in the analysis phase.

Application implementation approaches the mapping of design models to agents, behaviours and communication acts, concepts involved in the JADE framework, which is the adopted implementation platform.

3 APPLICATION SPECIFICATION

3.1 Concept Modeling

Infonorma is a system that provides its users with personalized recommendations of legal normative instruments. Each legal user has a profile composed by his/her own interests and identification. This profile is represented by a user model as an instance of the ONTOJURIS domain ontology.

Recommendations are based on legal normative instruments, the information items. Each one of these instruments has two main characteristics: the type and the category or legal branch in which it is classified. These characteristics are also part of the interests of legal users. The system monitors a legislative repository, a kind of information source composed by normative instruments.

Each legal normative instrument, as well as each legal user model, is represented as an instance of the ONTOJURIS ontology. ONTOJURIS is a domain ontology used to represent the structure of legal normative instruments. This internal representation is compared to the interests of the users in order to generate the recommendations.

All those concepts are represented in the Concept Model shown in Figure 1.

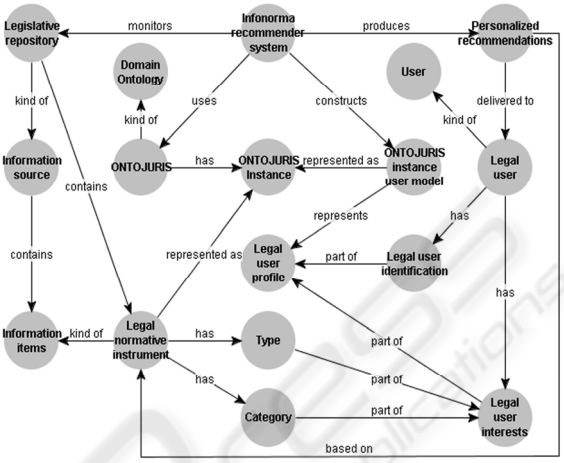

Figure 1: Concept model of Infonorma.

3.2 Goal Modeling

After applying the guidelines of MAAEM regarding the definition and representation of goal models in multi-agent systems to the area of content-based filtering, particularly for the legal domain, the following goals are captured:

- General Goal
  - Provide personalized legal-normative recommendations
- Specific Goals
  - Model legal users
  - Content-based filter of new legal information
  - Deliver recommendations

The complete goal model of the system is depicted in Figure 2. It is possible to realize that the general goal of the system is achieved by three specific goals, and, as requirements for the fulfilment of the specific goals, there is a set of responsibilities which need to be exercised in order to achieve the specific goals. Besides that, there are also external entities to the system: a *Legislative repository* and a *Legal user*. The legal information for content-based filtering users is obtained from a *Legislative repository* and the external entities representing legal users receives filtered items and provide some explicit information about their interests.

The fulfilment of the specific goal *model legal users* requires the exercise of *explicit user profile*

acquisition and the *user model creation* responsibilities. Similarly, in order to achieve the *content-based filter new legal information* specific goal it is necessary performing the responsibilities *user model creation* and *legislative repository monitoring*. The type of the normative instruments is explicitly specified in the ontology, but their categories are not.

Because of that, whenever new legal information items are identified, the system must find out in which legal branches they can be classified (*information items classification into legal branches* responsibility) so the *content-based similarity analysis* responsibility can be carried out. At last it is necessary to exercise the *filtered information delivery* responsibility.

The *Legal user* external entity represents the users of Infonorma. Such users are expected to be people interested in Law, more specifically in legal normative instruments, such as lawyers and judges. Such users are interested in certain legal branches and types of legal normative instruments which are more closely related to their work.

Originally, Infonorma used a Brazilian government website as information source. The lack of semantic markup of this source, entirely written in HTML, shortened the efficiency of the system. To overcome this problem a *Legislative repository* was built in OWL, according to Semantic Web standards, and an auxiliary application, using JENA framework (McBride, 2002), that converts the data of normative documents into an instance of ONTOJURIS in OWL format was developed.

This *Legislative repository* contains the normative instruments which are recommended to the users. It is important to state that the external entity is composed only by the instances of the legal normative instruments. The instances of user models are created and maintained internally by the system. The goal of ONTOJURIS is to represent legal normative instruments in the form of Semantic Web documents. It also represents various legal branches organized into a hierarchy so that the normative instruments can be classified according to it.

A legal branch is defined by a class that has four attributes: a name, which identifies it, a set of weighted keywords, the *specializes* and the *generalizes* attributes. The weighted keywords are terms that are semantically related to the branch. For example, *Crime* and *Penalty* are keywords for the legal branch Penal Law. They were determined with the aid of a domain specialist and are used to classify a given normative instrument. The first one (specializes) indicates the superclass (es) of a legal branch and the second one (generalizes), the subclass (es). Both of them have multiple cardinality, so multiple inheritance is allowed.

The *Legal Normative Instrument* class has the following attributes representing the structure of a normative instrument: the preliminary part, which identifies it; the normative part, in which the norms are found; and final part with some additional information about the normative instrument.

The User class has three main attributes. Each user is identified by its name. The recommendations are delivered through email messages, so it is important to annotate the email address. And, finally, the user interests, represented by a set of instances of legal branches.

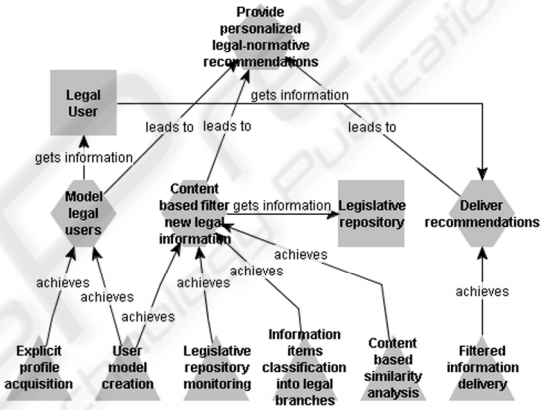

Figure 2: Goal model of Infonorma.

3.3 Role Modeling

Each one of the responsibilities identified in the Goal Model is assigned to an internal entity playing a role. This is expressed in a Role Model, which, due to space limitations, is not shown here. Each role requires, during its development, the usage and production of certain knowledge, the fulfilment of pre-conditions and post-conditions and specific skills. Each skill is detailed with a brief description and most relevant bibliographical references describing it.

The *Input Interface* role is in charge of the *explicit profile acquisition* responsibility. This responsibility uses the *user identification and interests* knowledge, to acquire the *Legal user profile*. The profile acquisition is made explicitly since there are not enough interactions of the user with the system to acquire his/her profile implicitly. On the top of that Infonorma is designed for users who know what they want but the desired information is not available in the moment, so it is

reasonable to have the users specify their interests. The specification of a new user profile is a pre-condition for the *explicit profile acquisition* that acquires a valid user profile.

The *user modeler* role is in charge of the *user model creation* responsibility. When a valid user profile is available, it creates an *ONTOJURIS instance user model* by instantiating the class "User Model" of ONTOJURIS with the information available in the *Legal user profile* produced by the first responsibility and the *User model* attributes acquired from the ONTOJURIS ontology.

The Source Monitor is the role responsible for the *legislative repository monitoring*, which uses the skill *information source update detection* to perceive changes in the *Legislative repository* to discover *new legal information items*.

The *information items classification* responsibility is assigned to the *Classifier* role that classifies the normative instruments into one or more legal branches assigning to each item the level of similarity with each legal branch. This is done by counting the keywords in the instrument and comparing them to the keywords of each legal branch.

The fifth responsibility is the *Content-based similarity analysis* one. The *Information Filter* role is in charge of it. The matching is performed by comparing the type of the new information items with the types each user is interested in. Once the information items are classified into legal branches the similarity analysis is performed by computing the distance between the legal branches the user is interested in and the legal branches the information item is classified in.

The last responsibility is the *filtered information delivery* one, assigned to the *Output Interface* role. Once the information items are filtered (pre-condition), the *Output Interface* produces the *personalized recommendations* knowledge. They are delivered to the user using the *Electronic mail message sending* skill.

3.4 Role Interactions Modeling

Each one of the Role Interactions Model shows the interactions related to each specific goal. The interactions are numbered according to their sequencing.

In the first role interaction model, related with the *model legal users* specific goal, the *explicit profile acquisition*, the user specifies his/her identification and interests to the *Input Interface* role that sends to the *User Modeler* the *Legal user profile* so it can get the *User model* attributes from *ONTOJURIS* and create the user models.

The second role interaction model is related to the *content based filter new legal information* specific goal. When any *information source change* occurs, the *Source Monitor* informs the *Classifier* about the *new legal information items* so that it can perform the *information items classification into legal branches* responsibility.

In order to perform the classification, the classifier must get the *ONTOJURIS legal branches.* Once the items are classified, they are sent to the entity playing the *Information Filter* role that performs the *Content-based similarity analysis responsibility*. When the *Information Filter* role receives those items, it requests the user models to the *User Modeler* one and the *ONTOJURIS legal branches* to the ONTOJURIS external entity.

At last, in order to deliver the recommendations, the *Information Filter* sends to the *Output Interface* the *filtered information items* which are sent to the *Legal User* as *personalized recommendations.*

3.5 User Interface Prototypes

According to the goal, role, and role interactions models, legal users interact with Infonorma for specifying their profiles (*explicit profile acquisition* responsibility). This interaction is supported by a Web form in which the user specifies his/her identification (login, email and password) and the types and categories he/she is interested in.

On the other hand, Infonorma provides legal users with personalized recommendations through the *filtered information delivery* responsibility. This can be considered as the output of the system and takes place when the filtered information is delivered to the user through email messages.

4 RELATED WORK

The state of art of the techniques used in recommender systems has been moving forward in the last years, improving considerably the effectiveness of these systems (Adomavicius and Tuzhilin, 2005).

A new research area, that has appeared recently, aims at improving the effectiveness of recommender systems using, as information source, semantically structured documents using technologies of the Semantic Web (Ziegler, 2004). Ontologies are the knowledge representation structures used by Semantic Web technologies. Work on the usage of

ontologies in user modeling and similarity analysis in recommender systems has already been developed (Middleton, Shadbolt, and De Roure, 2004).

A survey of current machine learning techniques for automatic text classification that can be used to classify information items into categories of the taxonomy is provided in (Sebastiani, 2002).

The agent paradigm can be exploited in the development of information filtering systems such as recommender systems. Experiences in this area are described in (Sheth and P. Maes, 1993).

There has been much work done in the domain of Artificial Intelligence and Law. The development and usage of legal ontologies to represent and access legal information has been addressed in (Tiscornia, 2001) and (Valente, 1995). (Benjamins, Casanovas, Breuker and Gangemi, 2005) provide an overview of the application of Semantic Web technologies to the legal domain.

5 CONCLUSIONS

This work described the requirements analysis of Infonorma multi-agent system. A solution to the requirements specified here was designed and implemented also under the guidelines of MAAEM methodology, although it is not described in this paper. The next step is to carry out tests with real legal users and define criteria for measuring the quality of recommendations.

In the current version of Infonorma users have to explicitly specify their interests by filling a form. This is used to create and update the user model and no feedback is obtained from the user. One research issue to be addressed in the future is to combine web usage mining techniques (Girardi and Marinho, 2007) with Semantic Web technologies to support the implicit acquisition of user profiles and their dynamic update through user feedback.

The case study described in this article also contributed for the evaluation of the MAAEM methodology application analysis phase.

Both MAAEM and ONTORMAS have proved their usefulness for capturing and specifying requirements of a specific application through appropriate guidelines and representation and decomposition mechanisms.

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