CONTROL MODEL OF DOMOTIC SYSTEMS BASED ON ONTOLOGIES

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Keywords: Ontologies, SWRL, Ambient Intelligence, Domotic, IntelliDomo.

Abstract: In the present paper we introduce the model process of an expert system for the control of domotic installations based on ontologies and SWRL rules. From the domotic system database where the attribute values of each device are stored, a background process converts these values into instances of the ontology representing the system. From these instances, a software application -known as DomoRules- allows creating production rules in SWRL language that will be useful to regulate the system. IntelliDomo draws inferences from the ontology and the SWRL rules by using behaviour parameters previously indicated by the user, so the state of the physic devices in the domotic system can be modified in real time.

1 INTRODUCTION

The use of Ambient Intelligence (AmI) is one of the areas which are rapidly gaining importance in the application of intelligent systems in companies and homes. One of the characteristics AmI systems seek is the gift of interaction with the user so that communication is as far as possible natural and the configuration of preferences takes less time for the user. AmI systems use behaving policies able to draw deductions with the information provided by certain devices and the represented rules. Moreover, they make decisions regarding the management of the installation.

The use of ontologies as representing bases, together with the representation of rules in SWRL in AmI systems, will provide the most precise definition of the taxonomy of physical devices that may exist in a system, the attributes of these devices and the possible relations among them. Furthermore, these representations will be more reusable by other users and will favor the completion of the classification of domotic components, the useful information to be represented upon these components and the connection rules that will allow deducting new information regarding the values of other components.

The amount of literature about intelligent domotic environments, which makes use of ontologies as representing bases, is poor. DomoML is one of the main reference works (Sommaruga et al, 2005)(Furfari et al, 2004); it is a markup language focused on defining a communication method among domotic devices.

Related to the previous project, DogOnt (Bonino & Corno, 2008) proposes a system able to recognize the devices that comprise the domotic environment automatically. DogOnt uses SWRL language to define rules that allow completing the ontology model which represents the domotic environment.

In these projects ontologies are used as representing bases of domotic devices and SWRL rules are used to maintain consistency in the information of the system components values. However, these production rules are not used to control general autonomous and real time functioning of the system.

The present paper introduces IntelliDomo, an AmI system based on ontologies for the control of domotic systems. It uses domotic components and its state values represented as instances of an ontology, and takes advantage of the power of the production SWRL rules specified by the user in order to change the state of the system components in real time. In section 2 of the present paper, we will describe the architecture of IntelliDomo and, in

A. Valiente-Rocha P. and Lozano-Tello A. (2010).
CONTROL MODEL OF DOMOTIC SYSTEMS BASED ON ONTOLOGIES.
In *Proceedings of the 2nd International Conference on Agents and Artificial Intelligence - Artificial Intelligence*, pages 470-473

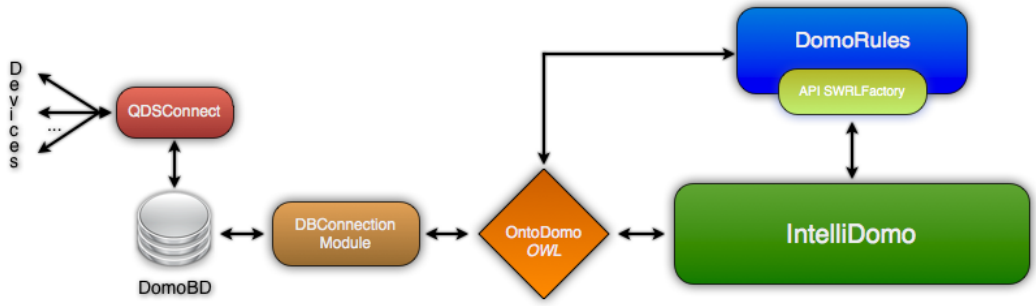

Figure 1: Overview of IntelliDomo Arquitecture.

its subsections, we will describe each of the components and tools of the model software. Finally, section 3 is dedicated to conclusions and future lines.

2 MODEL PROCESS FOR THE CONTROL OF DOMOTIC INSTALLATIONS BASED ON ONTOLOGIES

IntelliDomo is an expert system able to control the components of a domotic system automatically and in real time. It is based on an ontology called OntoDomo which contains the information about the devices of the system, on production rules in SWRL language which shape its behaviour and on a series of interconnection software tools, rules design and inference motor (see Figure 1).

The main characteristic of IntelliDomo is the ability of making decisions and reacting to the changes that arise in the elements of the domotic system. These decisions are taken based on the state of the system elements represented in OntoDomo and also on a set of established rules, expressed in the SWRL rules definition language. These rules can be modified by the user with the use of the DomoRules tool presented in the following subsection. In order to draw knowledge deductions, IntelliDomo uses Jess inference motor, this tool will allow inferring the concepts of the ontology and obtaining new data according to what it is stated in SWRL rules.

In order to manage this knowledge, IntelliDomo is built upon an ontology which concepts are related to the domotic components. The ontology has been modeled to be in sync with the physic devices that form a domotic environment, so that it can store its outstanding values and properties.

IntelliDomo has been designed to interact with an existing domotic database (DomoBD), where the state and values of the domotic components are updated in real time. This database can be obtained throughout the QDSConnect software module that has been developed by the research team from the Universidad de Extremadura, Quercus. This daemon provides the physic connection with EIB/KNX bus(http://www.knx.org). QDSConnect uses FALCON library to translate values of the physic devices into the relational database system and to detect any changes that may occur in the mentioned database in order to modify it straight in the physic devices.

Therefore, IntelliDomo can make deductions and update the domotic system instantly by transferring the new values from its hardware components to the database. DomoBD is the link between IntelliDomo and the physic domotic system. The information of this database is constantly translated into instances of OntoDomo by DBConnection Module. Similarly, when Intellidomo fires the correspondent rules, DBConnection Module updates DomoBD database, which will entail the respective changes of state in the physic devices.

2.1 OntoDomo Ontology

Nowadays, ontologies are the most used way of knowledge representation in different business or research projects in fields such as databases, intelligent information integration, cooperative information systems, information retrieval, electronic commerce, enterprise application integration, and knowledge management (Hepp, 2008). IntelliDomo uses ontologies as a representing base of domotic elements that constitute the system. These elements are stored in OntoDomo.owl, which

is responsible for reusing the knowledge of the rest of ontologies constituting IntelliDomo.

IntelliDomo allows the users to establish configurations able to guide the system behaviour and that are adapted to its needs and preferences. In order to do so, it uses an ontology that allows storing the configuration into profiles and to make inferences and reasoning able to incorporate new knowledge to the system. The ontology Preferences.owl is used with this end. Here, each user will be able to store his/her personal information for a certain situation: security, temperature, comfort... A series of variables defining the user's preferences can be established for every situation. For instance, as for temperature, the user will be able to specify that 'hot' ranges between 25 ºC and 36 ºC, consequently, these values will be used in the corresponding production rules.

Besides, the ontology Preferences.owl controls the so-called 'system variables'. These are control variables which could be used in SWRL rules to work with them and draw inferences. These variables work as global variables that will be shared by each user and known by the inference system in order to use them as a reference for certain decisions. These variables are identified with the symbol '#' prior to the name.

2.2 DomoRules Tool

SWRL is based on OWL ontology language, more specifically on the OWL-DL branch. It is a language able to build up rules to perform reasoning about the instances of an OWL ontology (OWL Individuals) and infer new knowledge about them.

DomoRules is a tool developed in Java that facilitates the creation of SWRL rules throughout API SWRLFactory. It provides a graphic interface appropriate to assist in the construction of these rules. It allows obtaining from OntoDomo all the necessary elements to build a SWRL rule (classes, instances, properties), to use SWRL variables and system variables that refer to the values defined by the user and finally to add SWRL language built-ins to the rules.

With DomoRules we seek to build SWRL rules easily without knowing the syntax of this language. All the elements constituting OntoDomo.owl ontology are introduced to the user in the interface, so that, by simply choosing a class or an instance, all the properties it has will be listed and the user will be able to pick the one he/she needs and establish its values in order to build the rules.

DomoRules is born aiming to offer the user a simple SWRL rules creating application. The task of designing an intuitive interface to abstract the SWRL language user is not easy because SWRL is a powerful language with a very rich vocabulary that provides high interaction with all its elements. Accordingly, by using DomoRules the user will be able to produce rules that shape the system behaviour that could be used by IntelliDomo.

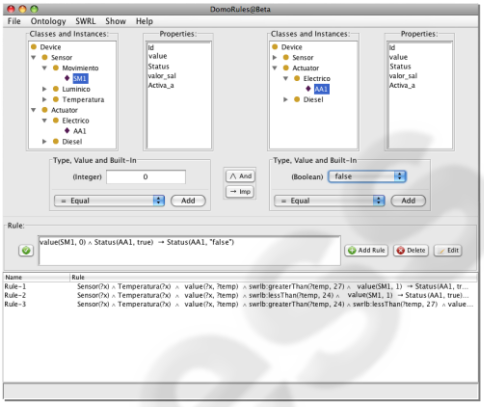

Figure 2: DomoRules creation rules interface.

2.3 IntelliDomo Module

IntelliDomo is the main control module of the system using the represented elements and the different modules which constitute the system. The information about configuration and location of the system can be observed graphically on a plan and, when the state of a device changes, a message alerts appearing upon the device icon. At the same time these events happen, it stores a set of log files where each of the actions carried out by the system and all the inferences it makes are detailed. It uses the DBConnection module to get connected to the different databases that constitute the application, which can be either DomoBD or the private databases IntelliDomo uses to store its own data.

3 CONCLUSIONS AND FUTURE LINES

Ontologies provide an appropriate kind of representation for identifying types and characteristics of domotic devices. Furthermore, production rules expressed in SWRL language allow establishing relationships among these domotic devices to shape the integral behaviour of a domotic

installation.

In the present paper, we introduce IntelliDomo. On the one hand, it is based on an ontology -known as OntoDomo- where all types of domotic devices, together with their useful characteristics, are represented; and, on the other hand, it is based on production rules in SWRL language defined according to the users' preferences and needs. With these knowledge bases, IntelliDomo allows managing the control of the domotic system itself. The state of the elements that comprise a determined domotic installation is continuously read from the database where its values are stored and translated into instances of OntoDomo ontology. With this information, together with the rules defined by the user, IntelliDomo's inference engine would fire the appropriate rules that will change the state of the system devices.

In addition to the IntelliDomo control module, we have developed DomoRules application, which works as a SWRL production rules generating wizard. The interface design has been developed aiming to be simple and intuitive for every user. As a result, the user may only select the type of component (a concrete physic component in the system) and the appropriate values to build the condition of the rule antecedent (body).

Nevertheless, we are inclined to provide IntelliDomo with a learning module where production rules would be modified according to the historical procedure of the users. The intention is that, meanwhile the user interacts with the system or some determined values are obtained under certain conditions, the rules can change or their execution precedes other rules. Therefore, once the user has established the reasonable importance of behaviour aspects, rules can be modified in order to adapt the system behaviour according to the importance of these criteria.

ACKNOWLEDGEMENTS

This work has been developed under support of Junta de Extremadura Project (PDT08A023)

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