Defining an Actor Ontology for Increasing Energy Efficiency in Smart Homes

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Problem statement

The topic of smart homes has become more and more popular over the last years. Besides the possibility to increase the energy efficiency of such homes by introducing automation technology to home environments, a smart home could furthermore support users in their daily life by remembering user preferences like room temperature or ambient light schemes as well as inferring new suitable preferences.

Since various aspects of such smart environments like multiple sensor and actuator data, user specific data and a high heterogeneity require a highly flexible technology which is able to deal with those kinds of data, semantic web technologies especially ontologies have caught more and more attention over the last years.
Using ontologies as underlying knowledge base enables the possibility to deal with context on all levels required within a smart environment as it can be divided into upper-level and lower-level ontologies.

The already existing ThinkHome system[1] implements various types of ontologies as well as a rudimentary actor ontology for representing actor information about the users in the system. Since this concept is primarily planned as multi-agent system in which intelligent actors can take autonomous actions on behalf of the users, this actor ontology can be either represent human users, but also system agents. [2]

Together with this already existing actor ontology which is currently in an alpha stage of its development and therefore quite incomplete, the module required to query the implemented ontologies called *KB Interface Agent* and mentioned in [1] has to be completed and implemented within the scope of this master thesis.

Expected results

The aim of this thesis is to develop a comprehensive actor ontology for smart homes which is capable of representing user actions, characteristics as well as storing user profiles in which the preferences of a specific user are stored.

Furthermore this ontology will then be fully integrated into the already existing ThinkHome framework to provide a more complete smart home system.

To enhance the usability of the integrated ontologies, it is planned to develop a prototypical implementation of a SPARQL module called *KB Interface Agent* which includes a SPARQL endpoint for performing generic queries on the KBs as well as predefined queries for previous elaborated use cases.

[1] https://www.auto.tuwien.ac.at/projectsites/thinkhome/overview.html

Methodological approach

After doing extensive research in the main topics of this master thesis like OWL, RDFS and SPARQL, which also will be briefly described in the first chapters of this work, the existing ThinkHome[2] concept will be investigated.

Once the use cases for actors in the smart home domain are clarified and documented, related ontologies will be evaluated to document their shortcomings and reusability in terms of the creation of a new actor ontology for increasing the energy efficiency in smart homes.

After developing the ontology, the previous defined use cases are evaluated by creating adequate SPARQL queries which are able to fulfill their respective use case requirements and then performed on the new created actor ontology. For this purpose a *KB Interface Agent* as mentioned in [1] will be implemented using Java and the Jena Library[3].

Since inferring new knowledge from gathered and measured data is a crucial task in smart homes, current state-of-the-art ontology reasoners will be evaluated and their performance on specific reasoning tasks compared to each other.

State-of-the-art

The idea of a smart home which is capable of reducing operating costs, increasing energy efficiency and increasing the living quality of its owners is not novel. Many different concepts were developed over the last years and have tried to tackle these requirements on many different ways.

MavHome[3] for example introduced an architecture consisting of agents which can be divided into several layers like *Information, Communication, Decision and Physical* which all have their own responsibilities. Unlike new approaches to introduce artificial intelligence to those agents using semantic web technologies, MavHome relies on algorithms named *SHIP (Smart Home Inhabitant Prediction)* or *ALZ (Active LeZi)* which are used to increase the living quality of its inhabitants.

Other smart environments use mathematical models to translate raw data into behavioral data which can then be used to detect unusual situations and events of its owners caused by disease or accidents.[7]

Modern smart home concepts like SESAME-S [6] or PlaceLab [5] use an ontology driven modeling approach to describe an energy aware home and the relationships between the objects and actors within the control environment. Similar to ThinkHome, their ontologies include a number of concepts such as location, appliance, sensors and pricing.

[2] https://www.auto.tuwien.ac.at/projectsites/thinkhome/overview.html
[3] http://jena.apache.org/

Connection to Information & Knowledge Management

There are several lectures in the curriculum of Information & Knowledge Management, which have their focus on topics related to those of this master thesis.

Topic: Semantic Web
Lecture: *Introduction to Semantic Web(188.399)*
General introduction into semantic technologies and ontologies as well as Description Logics and tool support for the Semantic Web.

Lecture: *Semantic Web Technologies(184.729)*
Deeper insights into languages, standards and technologies of the Semantic Web with focus on formal semantics. Furthermore an introduction into inference and querying on the Web, Semantic Web search and Linked Data.

Lecture: *Semi-Automatic Information and Knowledge Systems(188.387)*
Principles of ontology alignment, semantic integration and reasoning as well as an introduction to Semantic Web and ontology engineering

References

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