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Towards an Interoperable decision support platform for eco-labeling process

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Abstract. Along with the rising concern of environmental performance, eco-labelling is becoming more popular. However, the complex process of eco-labelling demotivated manufacturers and service providers to be certificated. In this paper, we propose a decision support system aiming at further improvement and acceleration of the eco-labeling process in order to democratize a broader application and certification of eco-labels. This decision support system will be based upon a comprehensive knowledge base composed of various domain ontologies covering the whole life cycle of a product or service. Through continuous enrichment on the knowledge base in modular ontologies and by defing standard RDF and OWL format interfaces, the decision support system will stimulate domain knowledge sharing and have the interoperability to be applied into other practice.

Keywords: Eco-labeling, knowledge sharing, interoperability, modular ontology, decision support system

1.1 Introduction

Since the late 1980s, there has been a growing demand from customers for products that do less harm to the environment. On the other hand, the public willingness to use buying power as a tool to protect the environment provides manufacturers with an opportunity to develop new products [1]. From a global point of view, promote of environment-friendly produce-consume-recycle progress will contribute not only to the life quality but also the economy itself. But how does a consumer, faced with numbers of products in the market, judge and make a good choice to reduce environmental impacts? How should we assess the validity of a statement about a product or service's environmental impacts? The need of evaluating a product's environmental performance has led to the establishment of eco-labels certificating a product or service that meets certain environmental criteria.

For an eco-label applicant, usually a manufacturer or a service provider, it is easy to provide the required information in whatever formats. However, the difficulties encountered in the evaluating processes are representative in decision-making processes. To efficiently assess certain product or service, we need indeed to manipulate different types of voluminous data; take in to account different criteria and conduct a multi-criteria analysis; consider different phases of product or service life cycle. Usually, a bunch of human experts coming from various domains will work together and the evaluating process will take a long time, and errors and conflicts may exist. In addition, the evaluation result is actually a good resource that could have been made better use of.

In this paper, we are interested in developing a decision support system in the scope of certificating or labeling process. The heterogeneous data and knowledge crosscovered in such process will be represented in ontology. The objective of this project is to build a decision support system that improve and accelerate the evaluation process of eco-labeling to help the domain experts make wiser decisions as well as reduce the costs of the process in order to finally democratize eco-labeling achieving a more eco-logical economic. Our approach is based on interconnected knowledge base composed of the identified domain knowledge by means of ontologies, which will provide a structured description of the domain concepts, relationships and rules covering the whole lifecycle of certain product or service categories. Taking advantages of ontology's semantic and interoperable nature, we can establish reference ontology that could be reused in other systems by extracting and refining modules from our system's knowledge base. In this approach, we will also develop distributed reasoning and inference mechanisms capable of traceable argumentation generation.

1.2 State of art

1.2.1 Eco-label and EU Eco-label

According to Global Eco-labelling Network (GEN), "Eco-labelling" is a voluntary method of environmental performance certification and labelling that is practiced around the world. An "ecolabel" is a label which identifies overall, proven environmental preference of a product or service within a specific product/service category. There are different classifications of labels. In contrast to "green" symbols, or claim statements developed by manufacturers and service providers, the most credible labels are based on life cycle considerations; they are awarded by an impartial third-party in relation to certain products or services that are independently determined to meet transparent environmental leadership criteria [2]. The International Organization for Standardization (ISO) has identified three broad types of voluntary labels, with eco-labelling fitting under the Type I designation [3].

Since the first eco-label with the name Blue Angel[1] awarded in Germany in 1978, many eco-labels covering various environmental aspects has been developed. To better manage and recognize eco-labels coming from different markets and countries, a Global Ecolabelling Network[2] (GEN) was even established in 1994 as a worldwide non-profit interest group whose goal is to foster co-operation, information exchange and harmonization among members. Driven by the guidance of government and society organizations, the number of products or services that are certificated by eco-labels are also increasing rapidly.

Eco-labelling has numbers of benefits from various points of view. First, eco-labeling is a good way to inform consumers of the environmental impacts of selected products. In the practice of some existent eco-labeling, the fitness of use and human health aspects are also included as well as the environmental performance. All these information will help a consumer make decision out of different willingness. Then, eco-labeling is generally cheaper than regulatory controls. By empowering customers and manufacturers to make environmentally supportive decisions, the need for regulation is kept to a minimum. This is beneficial to both government and industry [4]. Eco-labeling will also stimulate market development and encourage continuous improvement on product and service.

After a brief review of generic eco-label, we focus on the EU eco-label which relates to most of our research work. Created in 1992, the EU Eco-label is the only official European ecological label authorized for use in every member country of the European Union [5]. Until 2011, there are over 1300 enterprises that have been issued EU Eco-label licenses. By September of 2014, there are already over 43,000 products or services being labelled [6]. However, compared to the enormous Europe market, the awarded eco-labels are still too few. We consider that qualified enterprises should be encouraged to obtain eco-labels to become more competitive.

The Commission mandates the EUEB (European Union Eco-Labelling Board) to develop and regularly review eco-label criteria. The Commission issues a call for tenders resulting in the selection of an advisory body, and a workgroup is formed. The advisory body conducts a feasibility study and then proposes fitness-for-use criteria and environmental criteria. Consultation continues throughout the drafting of the specifications, alongside the feasibility study and the development of criteria concurrent with regular feedback to the EUEB. On completing the work for a given product category, the Regulatory Committee summons representatives from every Member State and votes on whether to approve the guideline [7]. The guideline developed by the advisory body, together with the possible amendment or annex will be the baselines for our knowledge base.

Throughout the product categories, the multi-criteria or guideline referred by EU Eco-label is usually stricter than the domain regulation. Such differences between EU Eco-label and standards consolidate its effect as a stimulation to the market and somehow a driving force as regards to the producer.

[1] https://www.blauer-engel.de/en

[2] http://www.globalecolabelling.net/

1.2.2 Knowledge-based decision support and modular ontology

The general decision supporting counts as a practical sub-branch of Artificial Intelligence. While it is still hard to define a clear border for decision supporting as various application of different levels can be found in various domains. Generally speaking, three fundamental components of a decision support system architecture are: database, model and user interface [8]. For each mentioned component, we can find good support from both theoretic and practical standpoint, as the traditional computer science and software engineering have been mature enough. In our research scope, we care about the database component, since the other two components are much related to specific business process, which depend on the field we will apply the decision supporting to.

Traditional database based on relationship model is becoming clumsy, especially in data exchange and inference aspects. With the rapid development of Semantic Web[3] and Linked Data[4], the interoperability, reusability and modularity of knowledge are becoming more and more important. As a result, ontology and ontology engineering has attract much attentions and efforts. In Computer Science, we refer to an ontology as a special kind of information object or computational artifact [9]. Studer et al. [10] gave definition stating that: “An ontology is a formal, explicit specification of a shared conceptualization.” For the notion of a conceptualization according to Genesereth and Nilsson [11], who claim: “A body of formally represented knowledge is based on a conceptualization: the objects, concepts, and other entities that are assumed to exist in some area of interest and the relationships that hold among them. A conceptualization is an abstract, simplified view of the world that we wish to represent for some purpose.”

In the last decades, so many ontologies and knowledge repositories have been developed, however, much problems are encountered when knowledge engineers as well as general users want to understand and employ the ontologies into their own software development. One reason of such difficulties is the semantic confusion among domains. Another reason, according to the author, is that there is still lack of a comprehensive and widely accepted standard system for ontology construction, e.g. ontology languages are developed based on logics having different expressiveness, which somehow block the compatibility for data exchange and reasoning. One of the thorniest problems is how we build ontology and utilize it to furthest maintain a well reusability. Due to the initial nature of being shared, certain formation of knowledge shall be meaningless if it could not be exploited and reused.

An interesting approach that deals with ontology reusability is the implementation of modularity, which reminds us of the similar term in software engineering. Modularization materializes the long-established complexity management technique known as divide and conquer. It is found in various areas of computer science. In the application of ontology, there is also a definite need from applications to gather knowledge from several, not just one, ontological sources. It

[3] http://www.w3.org/standards/semanticweb/
[4] http://www.w3.org/standards/semanticweb/data

is known that, when knowledge is distributed, the idea to collect all knowledge into a single repository (i.e. the integration approach) is very difficult to implement, because of semantic heterogeneity calling for human processing [12].

In our research, we will put much focus on how to connect existing modular ontologies, rather than the partitioning and extraction of modules. To achieve ontology modularity in a distributed scenario, E-Connection is proposed as a set of "connected" ontologies. An E-Connected ontology contains information about classes, properties and their instances, but also about a new kind of properties, called Link Properties, which establish the connection between the ontologies [13]. Another interesting approach is the use of Distributed Description Logics (DDL) framework [14] and the distributed reasoner DRAGO (Distributed Reasoning Architecture for a Galaxy of Ontologies) [15] as formal and practical tools for composing modular ontologies. Also, we have Package-Based Description Logics as another formalism that can support contextual reuse of knowledge from multiple ontology modules [16]. While these methods and formalisms more or less set up a logics syntax barricade that should limit a large scale reasoning and modification between heterogeneous and distributed modular ontologies, e.g. the underlying logics formalism of E-Connection is OWL-DL (i.e. SHOIN); while, logics formalism for DDL is SHIQ; when it comes to Package-Based Description, it turns into SHOIQ. From a practical perspective, these methods have not been applied in such a considerable scope that we could have successful application cases for a good study.

1.3 An interoperable decision support approach

Fig 1.1. presents a simplified outline of our platform for eco-labeling decision support. There are three roles as participant involved in our decision making process. First, at the top left of this schema, we have a human icon representing the applicant manufacturer or service provider who will initiate the eco-label application. On the right side another human icon represents the experts who take the results of the system and make the final decision whether the product or service is qualified or not. In the existent evaluating process, the member country's authorized Competent Body, human icon located at the left bottom, should first give advice and guideline to the applicant, in the meanwhile the applicant should prepare the required documents. In our schema, we trim off such routine operations because the concrete communication and administrative affairs have few concerns to the decision making.

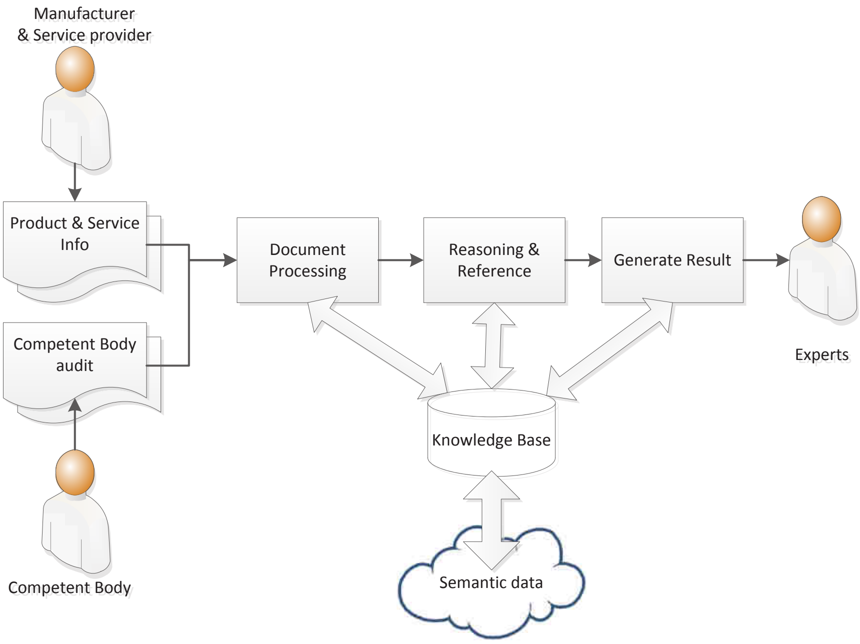

Fig 1.1. Outline of our platform for eco-labeling decision support.

Now we will follow a complete process to illustrate how we make use of the knowledge base to facilitate a product/service evaluation with traceable argumentation. Firstly, the applicant will provide a detailed description of their product or service. The competent body's audit result will also accompany with the description. In order to let the machine to understand the description, we propose a parser component to retrieve concerned information from the description to form a machine readable structured document. According to the understanding of the system, which is supported old cases and experience, the structured document will be transferred into a user ontology and then the system will select necessary domain ontology from the knowledge base. Towards these domain ontologies, a modularization and refinement formation proceeds to gather the very necessary knowledge parts to build a merged or integrated criterion ontology. In the next step, the inference component takes both user ontology and criterion ontology to test and verify if the user ontology that contains all the key description of the product comply with the corresponding guidelines. At last an argument tracer component will parse and translate the conflicts between user ontology and criterion ontology so as to generate the final report for human experts review. Then the task of our decision support system is finished and the following procedure will be the experts judge the results of the system and feedback to the applicant.

All the document processing, reasoning or generating process will be supported by a comprehensive knowledge base. The knowledge base is connected to other effective data source locally or remotely. All the data and knowledge will be serialized in multiple unified formats such as RDF or Turtle. To achieve a better interoperability performance, the knowledge base is equiped with public semantic data source accessing interface, which allows the ontology and data stored locally being accessed by other endpoint. In the opposite direction, our knowledge base is designed to be able to browse other knowledge base or ontology repository so as to acquire extra information. With such a open information sharing mechanism, we guarantee that part of our knowledge base shall be shared. This will be the cornerstone of interoperability when our decision support system is about to cooperate with other systems or is to be integrated into other systems.

1.4 The knowledge base in modular ontology

Single ontology may be not yet powerful enough to set up a complete conceptualization about the real world of Eco-labeling. Besides, as for knowledge's reuse possibility, modularize ontology into pieces is a reasonal choice and also a challenge. In our research, we choose only one product group at first implementation. Let's say "laundry detergent". If our methodology and system works well on single product group, then we should include more product groups.

For example, in EU Eco-labeling's conceptualization of the world of laundry detergent (Fig 1.2), we have a main conceptualization modular named "detergent" which hold the general concepts and properties of this domain. While, for other more specifc concepts, it reaches to other modulars via several dependencies (as with OWL 2, we can implement dependency by using "import" syntax, which means current ontology will use external concepts or relationships from the imported ontology. In software engineering, reducing dependencies between modules is one of the basic design rules). It's not difficult to see that several advantages exist in this modular design. As more coherent concepts and relationships are gathered together to form modules, it's easier to manage knowledge and data in large scale. Complex conceptualization can be achieved by composing multiple small modules. Also, it is easy to configure and replace modules rather than to alter small parts directly in a large structure. Take the same example in Fig 1.2. We have a general conceptualization of laundry detergent product which is stored in ontology module "detergent". We also have some general rules stored in the same "detergent" ontology. This principle ontology will "import" or make use of information of european commission regulation, ISO standards, and DIDList (Detergent Ingredient Database List), which could be possiblely used and imported by other ontology of other product group. Particularly, once DIDList ontology module is properly defined and developed in laundry detergent product group, it doesn't have to be redeveloped in hand washing detergent as it has identical reference to DIDList, thus we arrive at reusing some ontology modules such as DIDlist .etc.

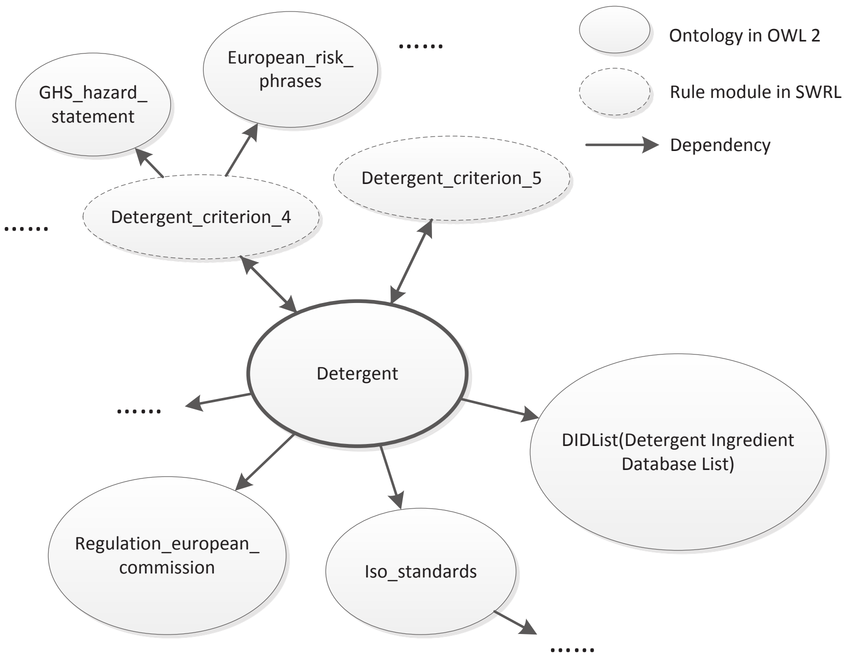

Fig 1.2. Ontology schema for EU Eco-label laundry detergent product group

Modularization implies separation and conceptualization, if we follow this path of thinking we can see that it will be practical to extract rules from ontology modular. In other words, it's better to keep objective constraints and world description separated. Take the detergent ontology example shown in Fig 1.2, ontology represented in ellipse with solid border are concept-centred, which means the main function of these ontology is to describe the concrete world. These ontology contains concepts and relationships that are edited to describe or record the fact about real world. There are indeed rules contained in such ontology modules, while they also serve mainly to describe rather than to judge or calculate. However, as for a product group guideline or criteria, quite a part of information are involved with human objectives. For the same detergent example, the concentration of different chemical ingredients has to respect to certain limit. In such cases, we can hardly say that such objective elaboration or goal-oriented specification are plain description of the world. Moreover, such rules or objective information may change time after time. This actually happens because, the product guideline keeps being updated as new EU Commission has always been generating new amendments or revise. In our approach, we have each criteria item to be an independent module (not totally independent, as we can see that these rule modules also have dependencies to other ontology modules), thus we can easily replace them with new rules and manage them in a configurable way.

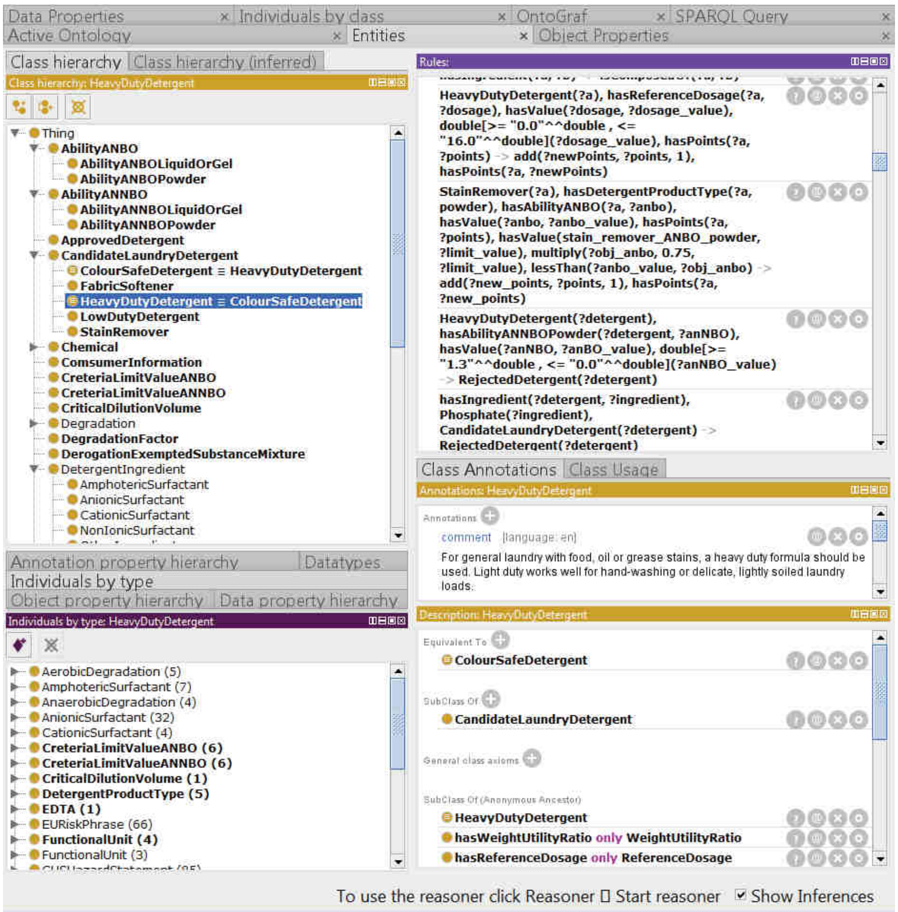

Fig 1.3. Composition of detergent ontology developed in Protege editor

1.5 Conclusion

In this paper we've seen what is eco-labelling. How an eco-labeled product or service shall contribute to the environment and economics. More specifically, a current status of EU Eco-label and its future trend are also presented. To popularize eco-labeled products and services in order to achieve a more competent and ecological economic, a better eco-labelling process is needed. We propose a decision support system that should improve and accelerate the evaluation process for eco-labeling to help the domain experts make wiser decisions as well as reduce the costs of the process. Our approach is based on a knowledge base composed of the identified domain knowledge by means of ontologies, which provides a structured description of the domain concepts, relationships and rules covering the whole lifecycle of certain product or service categories. The modularized knowledge base, which is key to the success of our decision support process, exposes part of its modules as reference ontologies that could be browsed or reused by other systems in order to achieve an data interoperability and knowledge sharing.

References

[1] Eco-labeling Markets. International Institute for Sustainable Development. http://www.iisd.org/business/markets/eco_labeling.aspx.

[2] Lefébure, A., & Rosales Muñoz, R. (2011). Communicating to consumers in Sweden with eco-labels: Is the message getting through?.

[3] GEN:Global Ecolabelling Network:What is Ecolabelling? http://www.globalecolabelling.net/what_is_ecolabelling/index.htm.

[4] Vilhelmiina Ihamäki, Eva van Ooij,Stefan van der Panne. (2014). Green Public Procurement in the European Union and the Use of Eco-Labels.

[5] The EU Eco-label scheme – What is it? http://www.ecolabels.fr/en/the-eu-eco-label-scheme-what-is-it.

[6] Facts and Figures – Ecolabel – European Commission. http://ec.europa.eu/environment/ecolabel/facts-and-figures.html.

[7] How are guidelines drawn up? – Ecolabel. http://www.ecolabels.fr/en/the-eu-eco-label-scheme-what-is-it/how-are-guidelines-drawn-up

[8] Druzdzel, M. J., & Flynn, R. R. (2003). Encyclopedia of Library and Information Science, chapter Decision Support Systems.

[9] Guarino, N., Oberle, D., Staab, S.: What is an Ontology? In: Staab, S., Studer, R. (eds.) Handbook on Ontologies, 2nd edn., pp. 1–17. Springer, Heidelberg (2009).

[10] R. Studer, R. Benjamins, and D. Fensel. Knowledge engineering: Principles and methods. Data & Knowledge Engineering, 25(1–2):161–198, 1998.

[11] M. R. Genesereth and N. J. Nilsson. Logical Foundations of Artificial Intelligence. Morgan Kaufmann, Los Altos, CA, 1987.

[12] Parent, C., & Spaccapietra, S. (2009). An overview of modularity. In Modular Ontologies (pp. 5-23). Springer Berlin Heidelberg.

[13] Grau, B. C., Parsia, B., & Sirin, E. (2009). Ontology integration using ε-connections. In Modular ontologies (pp. 293-320). Springer Berlin Heidelberg.

[14] Serafini, L., & Tamilin, A. (2009). Composing modular ontologies with distributed description logics. In Modular Ontologies (pp. 321-347). Springer Berlin Heidelberg.

[15] Serafini, L., & Tamilin, A. (2005). Drago: Distributed reasoning architecture for the semantic web. In The Semantic Web: Research and Applications (pp. 361-376). Springer Berlin Heidelberg.

[16] Bao, J., Voutsadakis, G., Slutzki, G., & Honavar, V. (2009). Package-based description logics. In Modular Ontologies (pp. 349-371). Springer Berlin Heidelberg.