Specialization of a Fundamental Ontology for Manufacturing Product Lifecycle Applications: A Case Study for Lifecycle Cost Assessment

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Abstract. This paper aims to study the specialization of a fundamental ontology describing manufacturing product lifecycle applications. This specialization is conducted through a case study of an Italian company. On the one hand this specialization is meant to define a specific ontology for LCC applications and on the other hand it aims to validate the mapping with the fundamental ontology implemented for manufacturing product lifecycle applications.

Keywords: Ontology, Specialization, Product Lifecycle Applications, Lifecycle Cost Assessment.

1 Introduction

In today's world of fast manufacturing, high quality demands and highly competitive markets, it has became vital for companies to be able to extract knowledge from their operating data, to manage and to reuse this knowledge in efficient and automated manner. Ontology has proven to be one of the most successful methods in fulfilling this demand. The most appealing features of the ontology are well-defined structure of the knowledge organization; being machine understandable enables automatic reasoning and inference and finally, well defined semantics enables easy interoperability. However, designing an ontology requires highly specialized knowledge experts working closely with the domain experts for, sometimes, significant period of time [1]. Within the context of a FP7[1] European project named LinkedDesign, a fundamental ontology has been designed to be easily adjusted and adopted for different product engineering systems [1]. Being generalized, this ontology needs to be specialized for each specific application. This paper aims to study the case of product lifecycle assessment. A specific ontology has been implemented and aligned with the fundamental ontology.

[1] Seventh Framework Programme.

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2 A Fundamental Ontology for Product Lifecycle Management Applications

2.1 LinkedDesign Fundamental Ontology

LinkedDesign[2] is a FP7 European Project within the context of Digital factories. It aims at providing an integrated and holistic view on data, persons and processes across the product lifecycle as a vital resource for the design of novel products and manufacturing processes. LinkedDesign Ontology – LDO is being designed to utilize knowledge extraction, structuring, exchange and reuse for 3 application scenarios with highly diverse products and activities. Such challenging task, resolved in a generalized solution which is applicable for almost every design and manufacturing business, after very light adjustment and installation. This significally reduces the resources needed for design of ontology from the beginning. The LDO conceptualization follows an iterative-incremental process based on the "NeOn" methodology [2], and it is implemented using Protégé[3]; the graph representation of the ontology is given in figure 1. Further details can be found in [3].

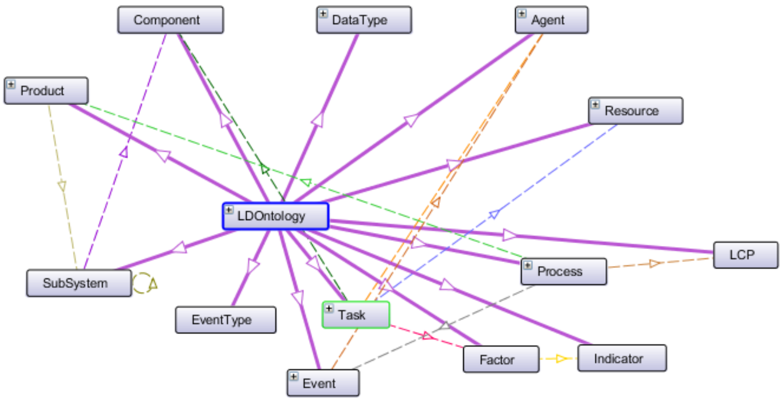

Fig. 1. The fundamental ontology

3 Specialization of the fundamental ontology: Lifecycle Cost Assessment Case Study

3.1 Lifecycle Cost Assessment

Lifecycle Cost Assessment – LCA applies to new products and do not necessary apply to those that are well developed. The lifecycle goes from the system concept definition up to the final disposal and it is divided into 5 phases as described in figure 2.

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[2] www.linkeddesign.eu

[3] http://protege.stanford.edu/

Fig. 2. Lifecycle phases

Lifecycle Cost - LCC is the total cost of ownership of a system during its whole operational life. LCC analysis and assessment is a key factor in product's early design phase.

3.2 Ontology Specialization for LCC Assessment

LCA is performed based on several information related to the lifecycle phases. Exploiting knowledge on LCC from previous projects is a key element to support this process. This requires exploring several projects documents and inputs. Providing access to the several existing data sources to analyze LCC can be enabled through a single entry point. This requires an integration of all data sources. Ontologies enable such integration through the usage of semantics and offer a global model for schema matching enabling therefore the integration of several data sources. The detail discussion on schema and ontology matching is beyond the scope of this paper and please refer to [4] and [5] for extended discussions.

Specialization for LCC Assessment. One of the high-level concepts in the fundamental ontology is "Factor" that groups relevant issues related to a product. One of these factors is the "LCC".

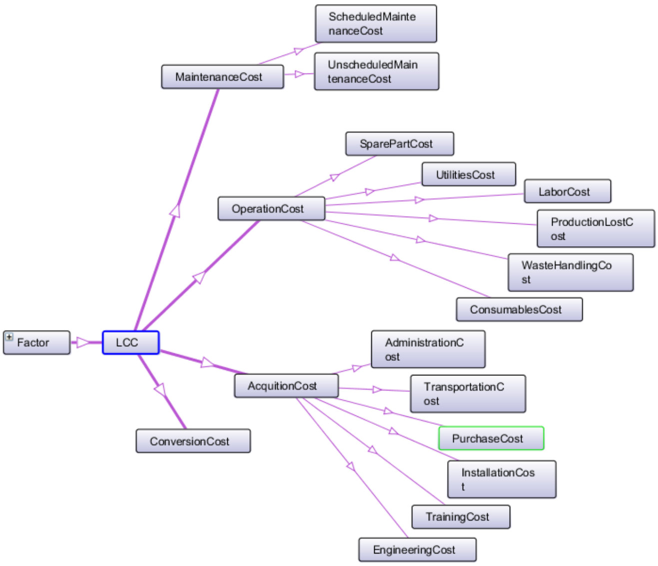

Fig. 3. The LCC specific ontology

The specialization process has been performed in two steps. The first consisted in defining the specific concepts related to LCC based on ORSD[4]. The second consisted in mapping the fundamental ontology and the specific ontology for LCC through the concept "Factor". The graph representation of the specific ontology is given in figure 3. This work is not an attempt at a complete representation and it is still on-going as it follows an incremental-iterative approach.

4 Conclusion and Perspectives

In this research we have experimented the specialization of a fundamental ontology for manufacturing product lifecycle applications. The concepts presented in the ontology covered the needs for the case of LCC Assessment specialization. Beyond the usage of a fundamental ontology and its specialization as a basis for knowledge representation, the future research will encompass the implementation of an LCA Design Support System for evaluating design approaches alternatives. Using ontologies has several benefits: (1) it represents a global model for schema matching through the usage of semantic mediation; (2) it provides several benefits by: (a) embedding additional and complex knowledge through the usage of rules; and (b) performing automatic reasoning and inference for extraction of embedded knowledge.

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