# Participatory Quality Management of Ontologies in Enterprise Modelling

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**Abstract.** The main research goal of this PhD project is developing a method that will improve the quality of an enterprise ontology by using business models during the ontology engineering process. We will investigate what quality of an ontology stands for, and how it can be improved by getting feedback from business models developed and used by a community that shares this ontology. We will base the development of our method on existing theory and real life cases where a community with different community members interacts with the ontology and modifies it according to their business models. Our goal in this PhD research is to find out the reasons why the community modifies an ontology and to make this process more automated.

**Keywords:** ontology quality, business model quality, ontology engineering, ontology improvement

## 1 Introduction

According to [1] ontologies are divided into three categories based on their level of generality: top-level, domain and application ontologies. *Top-level* ontologies are independent of a particular domain and describe very general concepts such as time. *Domain* ontologies describe terms related to a general domain such as medicine, sports, etc. *Application* ontologies describe terms related to a specific application. Those terms are often specializations of terms in related domain ontology.

In this research we will deal with an Enterprise ontology which we consider to be at the Application level because it specifies terms, facts and axioms of a particular enterprise. *Enterprise ontology* is a formal and explicit specification of a shared conceptualization among a community of people of an enterprise (or a part of it) [2]. Enterprise ontology must be coherent, comprehensive, consistent and concise. *Coherent* means that the ontology constitutes logical and truly integrant whole. *Comprehensive* means that the ontology is complete and covers all relevant issues. *Consistent* implies that the ontology is free from contradiction. The last aspect,

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*concise*, means that the ontology is being compact and contains no superfluous matters.

For this project it is important to understand the difference between an ontology and a model. A model is a representation of reality intended for some definite purpose [3]. And according to [3], a model is *prescriptive*, meaning that the reality is constructed according to the model itself. An ontology is *descriptive*; it only describes the reality, but the reality cannot be constructed from it. Models are designed with a specific functionality in mind, while ontologies simply describe a domain. Furthermore, ontologies are shared, while models are not.

This project will deal with a specific kind of model: a *Business Model*. Business model is a conceptual tool containing a set of objects, concepts and their relationships with the objective to express the business logic of a specific firm. Therefore we must consider which concepts and relationships allow a simplified description and representation of what value is provided to customers, how this is done and with which financial consequences [4].

An enterprise ontology describes all the terms, relations and axioms needed to develop business models. It is only a description of the structure, but it has no specific functionality in it. On the contrary, business model developers always have some functionality in mind. For example, Business Process [5] modellers always think of how to create a common approach for work to be carried out, and how to improve process efficiency. The enterprise ontology is indeed, very specific to a particular enterprise, but it is shared among different projects within this enterprise, while business model is very specific to one project. So, enterprise ontology serves as a reference to develop more concrete business models.

### 1.1 Research Questions

The main goal of this research project is to develop an ontology engineering method that will improve ontology quality by taking feedback from relevant business models. We can further divide this goal in the following research questions:

1. *Selection of business model quality evaluation framework that suites our needs.* This will be done by looking to available literature on business models' quality evaluation and interviewing people who are building and using business models to understand which evaluation criteria are the most valuable for them. We will choose the most appropriate framework and still may adapt it if needed.
2. *Selection of an appropriate ontology quality evaluation framework.* Will be achieved by looking to relevant literature and interviewing experts using ontologies in our case study. Ontology quality differs from model quality in the fact that the ontology is shared among different community members; therefore it serves different purpose and is evaluated using different criteria.
3. *Understand how business model development can affect ontologies that they are based on.* We will look to any available methods that link business models and ontologies, but mostly this question will be answered by working on our case studies where different partners are using the same ontology to build their own specific business models. We will interview those partners to gain a clear understanding of how they are working now and what they saw missing in the

ontology. Based on that we will know what business models can add to the ontology and which feedback from them we expect.

4. *Selection of a learning mechanism to be used in the ontology to enable it taking feedback from business models*. For that purpose we will look to available learning mechanisms and select the most suitable one based on the expected feedback from business models.
5. *Development and implementation of the ontology engineering method that will incorporate all the aspects mentioned above*.

## 2 Background

In the introduction we already defined the concept of enterprise ontology and business model. We believe that the link between those two concepts is very important. It is much easier to construct a business model when the bases are already available because enterprise ontology contains many of the necessary concepts and business modeller just needs to instantiate them. The enterprise ontology may contain some concepts that business modellers have not thought of while building the models. On the other hand, feedback from business models to the ontology will ensure generality of the ontology, so that it will contain an appropriate and complete set of terminology for every organization within this domain. After realizing the importance of business models' feedback to the ontology, we started to look for a method that can facilitate obtaining this feedback to increase the quality of an ontology and all the business models that are based upon it.

### 2.1 Model Quality

Quality of models is very important because models represent user requirements and are used as bases for building systems. In our project evaluating the quality of business models is important to prove that giving feedback from business models to the ontology will improve the quality of other business models created using the same ontology as a reference.

[6] defines model quality as the totality of features and characteristics of a model that bear on its ability to satisfy stated and implied needs.

The literature divides model quality into two types: process quality and product quality [11]. *Product quality* focuses on characteristics of the final product. Product quality criteria are used to inspect a finished product to find defects and correct them. *Process quality* focuses not on the final product, but on quality of the process used to build this product. The goal here is to add quality to the product while it is being produced rather than trying to find defects and correct them when the product is finished. In our research we will focus on product quality because we measure it look to the model only when it is ready instead of reviewing it while it is in the development process.

There are many quality evaluation frameworks in the literature such as Assenova, P., Johannesson [7], Poels and Dedene [8], Maier [9], Kesh [10] and Moody [11]. For example, Moody [11] framework highlights 8 quality factors: completeness, integrity,

flexibility, understandability, correctness, simplicity, integration and implementability. Every factor has a detailed metric for its evaluation. This framework was applied in [12] ensuring process quality by adding various review meetings during model development stage. Studying existing frameworks is important for us to compile a list of quality criteria from which we can choose the most relevant ones.

### 2.2 Ontology Quality

In our research we will develop a method that improves ontology quality by using feedback from business models. So, we need to evaluate quality of the enterprise ontology in hands to make sure that feedback from business models was useful. By looking into [13] we identified two ontology evaluation categories that are relevant (1) Using the ontology in an application and looking to the results, and (2) Comparing the ontology to a collection of documents containing information from the same domain.

For the first category, we consider business models as applications of the ontology and will evaluate the quality of the ontology by using it with relevant business models, taking feedback and evaluating the results. The second category is relevant to our research if we consider community's business models as a collection of documents. We will compare the ontology to those models to evaluate its quality.

An example of ontology evaluation framework similar to the model quality framework is [14] which evaluates ontology based on internal attributes such as Richness, Interoperability and Consistency. The authors are using those attributes to assess the external ontology attributes such as Usefulness and Performance. Some of the internal attributes used here are similar to the once used for model evaluation, such as Correctness, Consistency and Simplicity. But the ontology differs from models in the fact that it is shared among different projects and organizations therefore it must be evaluated using more general attributes. In [14] those attributes are *Authority* which stands for number of other ontologies linked to it, and *History* that stands for number of times the ontology was accessed. It is important to keep in mind that ontology evaluation differs from business model evaluation due to the functionality and the shared nature of the ontology. And which criteria to use for the evaluation depends on what is the purpose of a particular ontology and business model, and what the people (or agents) working with it need.

### 2.3 Problems in Research Field

While doing this research we realized that the field of ontology and business models has two main problems: (1) there is no way for the ontology to learn from relevant business models, and (2) the community is not sufficiently involved in ontology development and maintaining process.

With respect to the first problem, there is already some research about using enterprise ontologies to improve business modelling like for instance [15]. Those authors have chosen the Resource Event Agent (REA) ontology as a reference for

business modelling in accounting domain. The authors studied the REA ontology in details and redesigned the ontology using conceptual modelling language UML in order to use it as a reference for instantiating more concrete business models. Limitation of this approach is that no feedback from business models was taken to improve ontology quality. The ontology provides the basis for business model creation, but there is no means for the model to give any feedback on missing concepts in the ontology. If for example, a model needs a concept that is not in the reference ontology, this model cannot request adding the missing concept to the ontology. The same missing concept can be needed by other business models that use this ontology as a reference. Those other business models will include the missing concepts in a different format. If, for instance, the missing concept is "Price", one of the business models may use it as "Price" and another model may use it as "Cost". This will result in interoperability problems because there is no standard format for those missing concepts in the reference ontology. In this PhD we will overcome this problem by developing a method that allows taking feedback from business models in order to improve ontology quality.

The second problem is the fact that the community is not sufficiently involved in ontology development and maintenance. By community we mean all the people benefiting from particular enterprise ontology. Every part of this community has its own business models that can affect the ontology. The community aspect within ontology engineering was already considered by [16]. This research describes an ontology engineering method that incorporates the community in the process. The whole process happens in seven stages combined in two cycles: Semantic Reconciliation and Semantic Application. This process is represented in figure 1 below.

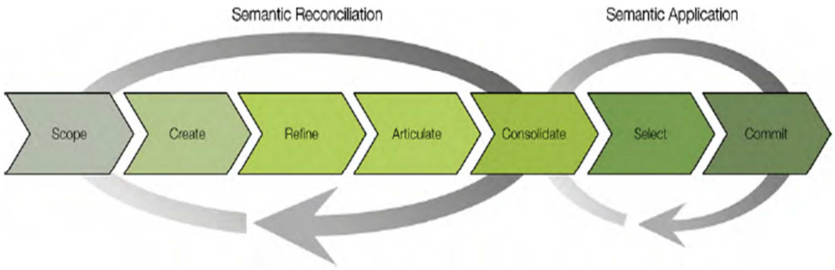


**Fig.1.** Ontology engineering stages, picture taken from [16]

During *Semantic Reconciliation* cycle community enters terms, relations and definitions relevant to a particular domain. Then those verbalized facts in natural language are converted to structured patterns. Those patterns are refined and articulated, and then a new proposal for the next version of an ontology is made. This proposal anticipates different community perspectives on the ontology.

The second cycle of this methodology is *Semantic Application*. During this cycle all the community members commit their information systems to the selected ontological pattern. Verification of commitments may result in a new version of the ontology.

A limitation of this method is that it involves the community only in ontology development stage. In the Semantic application cycle the users just commit their information systems to selected parts from the ontology, but they cannot modify the ontology if it contains mistakes. In the method that we will develop, this cycle will be more repetitive because business models can give feedback to the ontology and therefore modify it. When the ontology is modified, the Semantic application cycle starts again. So, in our research the community will be more involved in maintaining an existing ontology via community's business models.

## 3 Research Methodology

This PhD research will be executed in six stages based on Henver and Chatterjee [17].

**Identify the Problem and Motivate**
In this first stage we will justify that business modelling can provide an important feedback to the ontology. This will be done by conducting literature review and by using the Flanders Research Information Space case study [18]. The diversity of FRIS community helps us to achieve a better understanding of how community's business models can affect quality of the ontology. We will conduct systematizing expert interviews to extract process knowledge from representatives of different partners of FRIS to gain a better understanding on how they create their business models, how they interact with the ontology and which quality criteria are the most valuable for them in both ontology and business models.

**Define Objectives of a Solution**
Based on the literature review and the business cases, we will identify the requirements for a possible solution. Literature review will investigate the state of the art on enterprise ontology, ontology engineering, business modelling, quality evaluation of both ontology and business models and the existing methodologies that link ontologies and business models. This will help us to understand what is already available and we can possibly reuse to solve our problem. Meetings with community members will help us to understand their needs and what they expect from such participatory method.

**Design and Development of Solution**
At this stage we will design and develop our method based on the objectives defined in a previous step. Our method will assist business modellers to give feedback to the enterprise ontology that they use as a reference. First, our method will measure the quality of the business models, and then it will modify the ontology according to the feedback from those business models.

**Demonstration**
This stage will demonstrate that the problems are solved and the requirements are met. A prototype will be developed which extends an existing ontology engineering tool (i.e. Collibra Semantic Glossary). The prototype will be applied to different business cases where enterprise ontologies are used as theoretical bases for

developing business models. During the demonstration stage special attention will be paid to a feedback mechanism from business models to the ontology.

**Evaluation**
During the evaluation an experimental approach will be followed. The same enterprise ontology will be given as a reference to two different groups of business modellers. The first group will develop their business models using the enterprise ontology as a reference, but will not modify the ontology. This will be done using one of the existing methods that does not support taking feedback from business models, such as [15]. The second group will develop their models using our method that allows giving feedback and improving the ontology. When both groups are ready, we will compare the quality of both: the models and the ontology.

**Communication**
Scientific contributions at different phases of this project will be published in peer-reviewed journals and conferences. We also will engage in the relevant collaboration events initiated by the European commission's FP7 or other national projects/programs.

## 4 Preliminary Results

In this section we will present the preliminary results of this project by describing a preliminary version of our ontology engineering approach and presenting a first case study.

### 4.1 Ontology Engineering Approach

The main goal of our research is to develop a method that will improve quality of enterprise ontology by facilitating taking feedback from business models used in ontology engineering process. In this method we extended the work of De Leenheer [16] by incorporating ontology and model quality measuring frameworks, and increasing the involvement of the community by allowing the ontology to learn from community's business models. Our method is illustrated in figure 2 below.

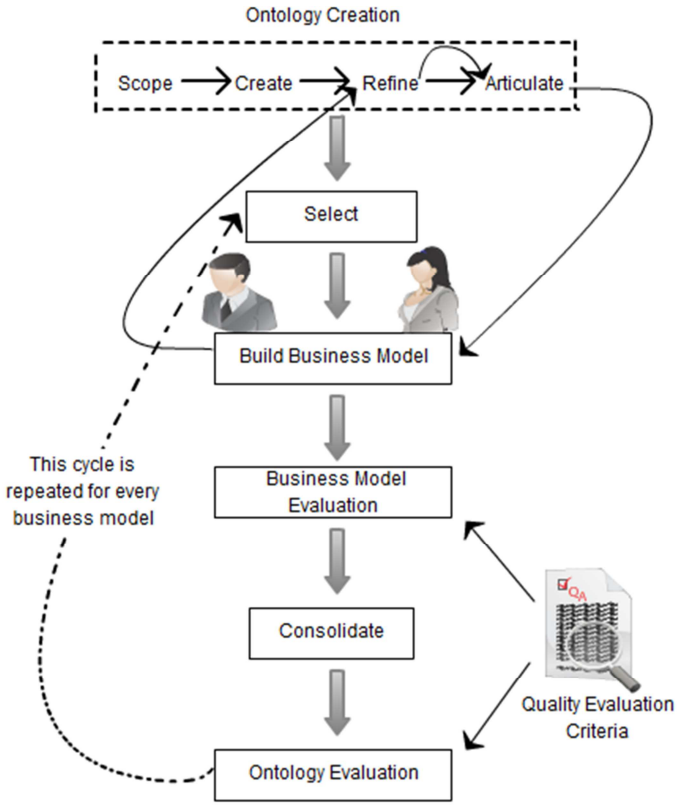


**Fig.2.** Our participatory method for ontology quality management in enterprise modelling

The first step in this method is *Ontology Creation* which includes the Semantic Reconciliation part from [16]. Here we assume that the resulted ontology has correct syntax and structure because creation of the initial ontology version is out of our scope. The next step is *Selection*, where a community member selects the relevant parts from the ontology. The third step is *Building Business Model*. Community members start building their business model using our method and based on the ontology parts that they have previously selected. During this step new terms that are not in the ontology, but are necessary for this community are refined, articulated and added to the ontology if found appropriate. The following step is *Business Model Evaluation*. The resulting business model is evaluated using appropriate quality criteria. This step is important because the community needs to be sure that the created model is worth using. At the *Consolidate* step, a new version of the ontology is available, enriched by the business model of the community and therefore representing this community's insights on a particular domain. During this step the analysis from the previous step are used to decide whether to go with the new version of the ontology or to keep the old one. The last step in our method is *Ontology Evaluation*. Here the new version of the ontology from the previous step is evaluated using selected quality evaluation criteria and framework. This step is important to

ensure that the feedback from business models is actually adding value to the ontology.

### 4.2 Case Study

Our first case study is the case of Flanders Research Information Space (FRIS) [18] which we will primarily use for problem identification and motivation. FRIS aims to collect and publish information on research entities such as researchers, research institutions and projects. This will reduce the administrative work of universities so that they do not need to report the same information in different formats. Currently FRIS offers some free services based on mash-up of data on main entities and their relationships. The main entities in FRIS ontology are Project Proposal, Project and Funding Program. For Syntactic interoperability FRIS relies on CERIF standards [19], and to add semantics it uses SBVR [20]. The ontology engineering method used is the one of De Leenheer [16] which is described in section 2 of this report.

FRIS has a diverse community of actors including high class actors such as minister of innovation, and middle class actors such as researchers and program managers. They must be given an opportunity to create and modify FRIS ontology. We attended a workshop at the Department of Economy, Science and Innovation (EWI) where people working on FRIS ontology where establishing a process model that shows the steps that community members must follow of modifying FRIS ontology. This workshop was very important for us to have a global view on how the ontology engineering process is going right now. So we can use this process in our interviews to see whether the community members are satisfied with it.

Our approach for now will be to meet different members of FRIS community and to interview them.
We will ask every community member questions such as:

- Did you use any business models for your system? If not, would it be useful to have one?
- Did you have any difficulties dealing with FRIS ontology?
- What do you want to modify in the ontology?
- Do you agree with the process model proposed by EWI for ontology modification?
- Which criteria are the most valuable for you in model and ontology quality evaluation?
- What is more important for you, process quality or only the final product quality?
- Do you communicate with other partners of FRIS?
- If you communicate with other partners, do you have any interoperability problems?

Those questions will help us to understand the needs of the community and to gain an insight on how the partners are currently working. After we are finished with the interviews and the literature, we will use this insight to specify initial requirements for our method.

Till now we had an interview with a partner of FRIS who is responsible for a system (R&D-net) that keeps track of researchers and publications at Vrije Universiteit Brussel (VUB). In this interview we asked the questions above, adapted to our interviewee.

As the result of this interview we realized that R&D-net was built upon CERIF model, the same one that was used for FRIS ontology. Any mismatches are currently solved by mapping R&D-net classifications to FRIS classifications. So, instead of trying to modify the ontology, they just construct mappings. At that point the interviewee does not really interact with the ontology; he just exports XML of his information system to FRIS. The most important problem that they face now is that they do not have clearly defined relations between classifications in their system. They cannot depend on the ontology in that because the ontology is regarded as a very general semantic repository and contains only 9 concepts while R&D-net system includes around 120 tables. We showed the interviewee a list with model quality criteria and asked him to pick the most important ones. He chose integrity, flexibility, correctness, suitability for solving a problem, consistency, validity, clarity and accuracy of the model. Currently VUB FRIS partner does not interact with any other partners of FRIS.

In general, the interview was informative, but the interviewee was from the IT part of this project therefore he was not really concerned about enriching the ontology from business models, though he agreed that this would be useful. As a next step we will find a person who is responsible for business models at VUB to get more details.

We will keep conducting interviews like those, with other partners till we have a clear view on how they work, how their models can enrich the ontology and which quality criteria are the most relevant for them. After that we will develop our method for improving quality of ontology with a help of business models used in ontology engineering phase. This method will be demonstrated and evaluated using other case studies.

## 5 Conclusions

In this report we describe a research project which has as main goal the development of a method for improving the quality of enterprise ontology by using business models during the ontology engineering process. The method must allow taking feedback from relevant business models to the ontology which will enrich the ontology and improve its quality. Moreover, the method gives the community an opportunity to be involved in ontology development and maintenance through community's business models. Currently we are further identifying and motivating the research problem using existing literature and a first case study. The latter has a subject the FRIS ontology and investigates how this enterprise ontology interacts with the business models developed and used by the community. The result of literature review and the interviews will be used to define the requirements for the ontology engineering method which in later phases will be implemented, demonstrated and evaluated using different case studies.

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