Semantic Enrichment of Enterprise Models by Ontologies-based Semantic Annotations

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Semantic in enterprise modelling

The problem to solve:
• the lack of semantics in enterprise models

The purposes:
• Determine where the semantic conflicts stand within the enterprise model creation process
• Propose a methodological approach to follow to the semantic enrichment of enterprise model.
Enterprise modelling

- Enterprise modelling aims to construct a model of whole or part of the enterprise, and generally of any organization, considered as a system, to explain the structure and the organization or to analyze their behaviour.

- Formalization degree of the models varies according to the languages used, it can be:
  - informal (such as natural language),
  - semi-formal (such as language with graphic formalism),
  - formal (mathematical language).

=> Enterprise Models : Semi-Formal
Enterprise modelling semantic problems

Semantic problems:
• Semantic of enterprise modelling language concepts
• Semantic of particular Enterprise model content (Company specific information)

Actors concerned:
• Researchers in EM community
• Expert of a particular EM language
• Enterprise business users
## EM semantic problem vs. actors

<table>
<thead>
<tr>
<th></th>
<th>Semantic of EM Languages</th>
<th>Semantic of EM model content</th>
</tr>
</thead>
<tbody>
<tr>
<td>EM researchers</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>EM Expert (on one particular language)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>EM business users</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
## Semantics and semantic conflicts types

<table>
<thead>
<tr>
<th></th>
<th>( T_1 = T_2 )</th>
<th>( T_1 \neq T_2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( D_1 = D_2 )</td>
<td>Equivalence</td>
<td>Synonymy</td>
</tr>
<tr>
<td></td>
<td>No Conflict</td>
<td>Low Conflict</td>
</tr>
<tr>
<td>( D_1 \cap D_2 = D_2 )</td>
<td>Additional</td>
<td>IS-A</td>
</tr>
<tr>
<td></td>
<td>Medium Conflict</td>
<td>Medium Conflict</td>
</tr>
<tr>
<td>( D_1 \cap D_2 \neq 0 ) ( D_1 \cap D_2 \neq D_2 ) ( D_1 \cap D_2 \neq D_1 )</td>
<td>Overlap</td>
<td>Overlap</td>
</tr>
<tr>
<td></td>
<td>Major conflict</td>
<td>Major conflict</td>
</tr>
<tr>
<td>( D_1 \cap D_2 = 0 )</td>
<td>Homonymy</td>
<td>Disjointness</td>
</tr>
<tr>
<td></td>
<td>Low Conflict</td>
<td>No Conflict</td>
</tr>
</tbody>
</table>

\( \Rightarrow \) Two different terms mean the same concept  
\( \Rightarrow \) One same concept has two different terms

(Adapted from Kavouras, 1992)
The semantic continuum

- **Tacit semantic** which exists only in people mental;

- **Semi-informal semantic** (explicit and abstract), it is explicit but is often represented in an abstract way by generally using natural languages such as English or French;

- **Semi-formal semantic** indicates an explicit and relatively formal semantics which is intended mainly for human by using generally graphic formalisms such as the semantic models, UML diagrams, etc.;

- **Formal semantics** is based on rigorous mathematical formalisms (such as the description logic, first order logic, etc.) which enable to treat it in an automatic way.
## Semantic conflicts compared to semantic continuum

<table>
<thead>
<tr>
<th>Semantic Conflict</th>
<th>Tacit</th>
<th>Semi-informal</th>
<th>Semi-formal</th>
<th>Formal</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
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</table>
Model-creating process as knowledge-creating process

SECI model (Nonaka, Toyama and Konno)
enterprise modelling process

1. Obtaining the necessary information to modelling
2. Construction and review of the preliminary model
3. Formalisation of the final model (design)
4. Explanation and justification
Semantic Conflicts in enterprise modelling

Semantic conflicts in enterprise modeling

1. Obtaining the necessary information to modelling
2. Construction and review of the preliminary model
3. Formalisation of the final model
4. Explanation and justification
Semantic enrichment of enterprise models

Need an additional component to the enterprise model that will enable him to overcome semantic conflicts.

The component must allow each entity involved in enterprise model to carry an explicit semantics during its life cycle.

ONTOLOGIES-BASED SEMANTIC ANNOTATION
Ontologies

An ontology is an explicit and formal specification of a conceptualisation of a domain of interest

The languages used for the construction of ontology may be classified in the same manner than the enterprise languages:

- informal (understandable for the user but difficult to check the absence of redundancy or contradiction);
- semi formal (increased clarity and reduced ambiguity);
- formal (possibility to check redundancy and consistency)
Complementarities and mapping

<table>
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<tr>
<th>Differences</th>
<th>Enterprise modelling</th>
<th>Ontologies</th>
</tr>
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<tbody>
<tr>
<td>• Enterprise modelling research are mainly informal</td>
<td>• Ontology technique is formal</td>
<td></td>
</tr>
<tr>
<td>• Don’t allow to capture precisely the semantics of the concepts</td>
<td>• Allows better defining the semantics of the concepts</td>
<td></td>
</tr>
<tr>
<td>• represents the structure or the operation of the enterprise</td>
<td>• organizes the concepts used and the relations between them</td>
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Similarities: Concept Identification

Differences:
- Enterprise modelling research are mainly informal.
- Don’t allow to capture precisely the semantics of the concepts.
- Represents the structure or the operation of the enterprise.

Ontologies technique is formal.
- Allows better defining the semantics of the concepts.
- Organizes the concepts used and the relations between them.
Semantic enrichment of enterprise model

Reference Ontology

S.A
• AT:
• TDA:
• LTA:
• FDA:
• GDA

Enterprise model

S.A: Semantic annotation
AT: Annotation type
TDA: Textual description of annotation
LTA: Location of the target of annotation
FDA: Formal description of annotation
GDA: Graphic description of annotation
Structured approach for semantic enrichment of models

Constitute the team

Define RO

Validation

Delineated EM concept

Validation

Match EM concept to RO concept

Validation

Construct annotation

Validation

Deploy enrich model

Validation
Constitute the team

2 teams

- enterprise domain
- enterprise modelling
- ontologies
- semantic annotations

- execution team
  handle the enrichment tasks

- supervision team
  validation at each step of enrichment
Define RO

The steps to follow to create ontology are:

• Determine the field and scope of the ontology, the degree of formalisation, choose an ontology language.
  => Study the possibility of using existing ontologies, to extend and refine them (could be a requirement).

• Enumerate the significant terms (in a list form: all the terms to be treated or explained to a user, and the properties related to these terms).

• Define the classes and their hierarchy.

• Define the class properties (attributes) and their facets (values types, authorized values, number of values, etc.).

• Create class instances in the hierarchy.
Allocate to the model enterprise concepts the right definitions to provide annotated them to the adequate good reference ontology concept.
Enterprise model concepts must be linked to those of the ontology that correspond in a most adequate way. This correspondence is based on the definition that we gave to each model concept in the previous step.
Semantic annotation includes the following elements:

- **Identification of the annotation**;
- **Annotation type**:
  - **Decoration**: annotations are comments associated with the resource;
  - **Linking**: annotations are links;
  - **Instance Identification**: the annotated object (U#X) is an instance of a given class and the annotation content (Ref2Ontology) may be a link to that class (uri);
  - **Aboutness**: no assertion is made about the existence of an instance of the concept, but there is a loose association with the concept;
  - **Pertinence**: the target of the annotation may be of interest for the annotated object.
- **Textual** (human readable) description of the annotation content;
- **Identification/location** of the target of the annotation (example: link to an ontology); Formal definition of the annotation content. The value of this formal definition depends on the types of the annotation. This part of the annotation scheme is intended to be machine readable and interpretable.
- **Graphic description** of the annotation: graphic representation of the annotated concept is given related to the reference ontology.
Deploy enrich model

collect all the information built in the previous steps to form the enriched model with all the annotations that connect model elements to their equivalent ones in the reference ontology.
On-going work

Objective: Prove the usefulness of Semantic annotation of enterprise model

Measuring the gap of understanding of two enterprise models through one unique group of people:

=> Not-semantically annotated enterprise model
=> Semantic annotated enterprise model
Conclusion

• Connection between enterprise modelling process and the conversion knowledge model (SECI) were determined.

• Similarity and complementarities between Enterprise Modelling domain and Ontology domain accessed

• Semantic conflict in enterprise modelling were revealed. It is due to the semantic lack of the enterprise models.

• A methodological approach of semantic enrichment was proposed.
Reference Ontology

• an ontology is as a 4-tuple \(<C, R, I, A>\):
  
  • C is a set of concepts,
  • R is a set of relations,
  • I is a set of instances,
  • A a set of axioms.

• reference ontology has to contain the concepts which are in the enterprise model.
Semantic Annotation

• The semantic annotation is a particular case of annotation because it refers to ontology. It can be made in the form of comments, of explanations note, questions or another type of external remark which can be attached to a document or a selected part of this document.

• To perform an annotation it is necessary to proceed through the three following phases which are:
  • The location which consists in placing in the document the ontology concepts references that it contains. These elements are considered as meta-data,
  • The instantiation which allows to give attributes values of the concepts using information present in the document,
  • The enrichment which aims at adding information by means of concepts attributes which could not be given values in the previous phase.