Ontology-Driven Conceptual Modeling

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IAOA Summer School
Trento, Italy, 2012
Day 1
ONTIOLOGICAL FOUNDATIONS FOR STRUCTURAL CONCEPTUAL MODELS

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About

Created in 2006, NEMO (Núcleo de Estudos em Modelagem Conceitual e Ontologias) is a research group devoted to investigating the application of domain and foundational ontologies as well as ontology-based techniques in various aspects of conceptual modeling such as information modeling, enterprise modeling, agent-based systems and semantic web. We have been establishing a productive partnership with industry regarding the application of ontologies in sectors such as domain engineering, software engineering and Energy (Petroleum and Gas). Moreover, in the past three years, NEMO members have been actively participating in the consolidation of the Brazilian Ontology Community by carrying out activities such as the organization of some of the first scientific events devoted to ontologies in Brazil.

NEMO has integrated the former LABES (Software Engineering Research Laboratory). LABES was funded in 1999 with the prominent purpose of investigating the application of ontology-based techniques in Software Engineering. In this area, one the key projects conducted inside this laboratory was the ODE (Ontology-Based Development Environment Project). This project investigated the use of domain ontologies for domain engineering and for the systematic development of semantically-aware object-oriented frameworks. This project resulted in a number of formal ontologies for several software engineering sub-domains (e.g., software requirements, software process, software quality, risk analysis, etc.). Once produced, these domain ontologies have been employed for the production of reusable frameworks for each of these domains. Finally, these frameworks were used for the production of a process-centered semantic software engineering integrated environment. Since 2003, the laboratory has also been involved in the development of projects in the use of ontologies (both as a reference framework as a knowledge representation artifact) for providing intelligent support in software engineering knowledge management. Since 2006, the LABES has been integrated to the recently created NEMO (Ontology and Conceptual Modeling Research Group).

Senior members:

- Dr. Giancarlo Guizzardi (Foundational Ontologies, Conceptual Modeling)
- Dr. Renata Silva Souza Guizzardi (Multi-Agent Systems, Constructivist Knowledge Management, Goal-Based Modeling)
- Dr. Ricardo de Almeida Fabo (Ontologies in Software Engineering, Ontological Engineering, Software Process and Quality)
What is Conceptual Modeling?

“the activity of formally describing some aspects of the physical and social world around us for purposes of understanding and communication...Conceptual modelling supports structuring and inferential facilities that are psychologically grounded. After all, the descriptions that arise from conceptual modelling activities are intended to be used by humans, not machines... The adequacy of a conceptual modelling notation rests on its contribution to the construction of models of reality that promote a common understanding of that reality among their human users.”

John Mylopoulos
Young and Kent (1958)

- Information set/item
- Defining relationship
- Producing relationship
- Conditions
- Temporal aspects
Why the need for an abstract formalism?

“Since we may be called upon to evaluate different computers or to find alternative ways of organizing current systems it is necessary to have some means of precisely stating a data processing problem independently of mechanization.”
E-R Diagrams (1976)
A sample NIAM schema (Faulkenberg and Nijssen)
Common Trends

- *Natural Language* and *Cognition* do play an important role
- The idea of an *abstraction* mechanism to focus on aspects of the domain (as opposed to aspects of implementation)
- There is an implicit ontology in all these cases
KL-ONE (Brachman, 1979)
The opposite to Ontology is not Non-Ontology is Bad Ontology!
Ontologies in Information Sciences

Foundations of data modeling by S. H. Mealy (1967): three distinct realms in the field of data processing, namely: (i) “the real world itself”; (ii) “ideas about it existing in the minds of men”; (iii) “symbols on paper or some other storage medium”.

Kent’s Data and Reality (1978)
BWW approach (1987)
Data and Reality

William Kent
Orgão

contrato

possui

serviço

produto

prestador

valor

orçamento

possui

orgão

contrato

serviço

prestador

valor

produto
Admissible state of affairs according to the conceptualization underlying Ontology $O_1$

State of affairs represented by the valid models of Ontology $O_1$

Admissible state of affairs according to the conceptualization underlying Ontology $O_2$

State of affairs represented by the valid models of Ontology $O_2$

FALSE AGREEMENT!
representation

interpretation

semantic distance ($\delta$)
when $\delta < x$ then we consider the communication to be effective, i.e., we assume the existence of single shared conceptualization.
\( \delta \)
Small $\delta$, Small Ontology

Big $\delta$, Small Ontology

Small $\delta$, Big Ontology

Big $\delta$, Big Ontology

Well-Founded Techniques

Matching & Alignment Techniques
Small $\delta$, Small Ontology

Big $\delta$, Small Ontology

Small $\delta$, Big Ontology

Big $\delta$, Big Ontology

Well-Founded Techniques

Matching & Alignment Techniques

Some Flexibility

Intractable!
a catalog
a set of text files
a glossary
a thesaurus
a collection of taxonomies
a collection of frames
a set of general logical constraints

complexity without automated reasoning
with automated reasoning
We need to recognize that *There is not Silver Bullet!* and start seeing ontology engineering from an engineering perspective.
“What are ontologies and why we need them?”

1. *Reference Model of Consensus* to support different types of *Semantic Interoperability Tasks*

2. Explicit, declarative and machine processable artifact coding a domain model to enable efficient automated reasoning
A Software Engineering view...

![Diagram showing Conceptual Modeling connected to Implementation₁, Implementation₂, and Implementation₃]
A Software Engineering view...

Conceptual Modeling

Design

Implementation$_1$
Implementation$_2$
Implementation$_3$
...transported to Ontological Engineering

Ontology as a Conceptual Model

Ontology as Implementation\textsubscript{1} (SHOIN/OWL-DL, DLR\textsubscript{US})

Ontology as Implementation\textsubscript{2} (CASL)

Ontology as Implementation\textsubscript{3} (Alloy, F-Logic…)

nemo
...transported to Ontological Engineering

Ontology as a Conceptual Model

DESIGN

Ontology as Implementation$_1$ (SHOIN/OWL-DL, $DLR_{US}$)

Ontology as Implementation$_2$ (CASL)

Ontology as Implementation$_3$ (Alloy, F-Logic…)

nemo
We need a proper Conceptual Modeling Language

We need a representation system whose system of modeling primitives reflect the distinctions of an appropriate underlying (descriptive) ontology
Concept (conceptualization)

- represents
- abstracts

Symbol (language)

refers to

Thing (reality)
Concept (conceptualization)

represents

Symbol (language)

refers to

abstracts

Thing (reality)
Domain Conceptualization

interpreted as

represented by

Modeling Language

used to compose

Domain Abstraction

used to compose

instance of

Model

represented by

interpreted as
by Marks and Reiter, 1990
Domain Conceptualization

Domain Abstraction

represented by

interpreted as

used to compose

instance of

used to compose

Modeling Language

Model
Admissible state of affairs according to a conceptualization C
{\exists x \text{ Person}(x), \exists x \text{ Father}(x)} (MM_{nemo})
Admissible state of affairs according to a conceptualization $C$

State of affairs represented by the valid models of metamodel $MM_1$ of language $L_1$
\{\exists x \text{ Person}(x), \exists x \text{ Father}(x)\} (\text{MM}_1)\\

\{\exists x \text{ Person}(x), \exists x \text{ Father}(x), \forall x \text{ Father}(x) \rightarrow \text{ Man}(x), \forall x \text{ Person}(x) \leftrightarrow \text{ Man}(x) \lor \text{ Woman}(x), \neg \exists x \text{ Man}(x) \land \text{ Woman}(x), \ldots\} (\text{MM}_2)
Admissible state of affairs according to a conceptualization $C$

State of affairs represented by the valid models of metamodel $MM_1$ of language $L_1$

Admissible state of affairs according to a conceptualization $C$

State of affairs represented by the valid models of metamodel $MM_2$ of language $L_2$
\{\exists x \text{ Person}(x), \exists x \text{ Father}(x)\} \ (\text{MM}_1)
State of affairs represented by the valid models of metamodel MM₁ of language L₁

Admissible state of affairs according to a conceptualization C

State of affairs represented by the valid models of metamodel MM₂ of language L₂

State of affairs represented by the valid models of metamodel MM₃ of language L₃

Admissible state of affairs according to a conceptualization C
Admissible state of affairs according to a conceptualization C

State of affairs represented by the valid models of metamodel MM₁ of language L₁

Ontology of the domain according to the conceptualization C

State of affairs represented by the valid models of metamodel MM₃ of language L₃

State of affairs represented by the valid models of metamodel MM₂ of language L₂
Additional References


