Formalization and evaluation of the interoperability relationship of product-centric information systems

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- CRAN - 1

Agenda

1. Background
2. The main issues
3. Objectives
4. Proposed approach
5. Future work

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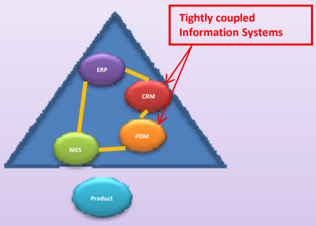
Background

From one monolithic Information System (IS) composed of tightly linked components

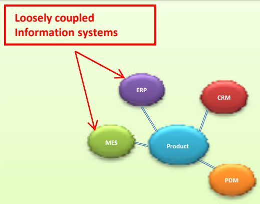
To a set of heterogeneous and autonomous IS aggregated into one SoIS

Fully integrated System (CIM)



The product is completely outside without any predefined link with the fully integrated system

System of Information Systems (SoIS)



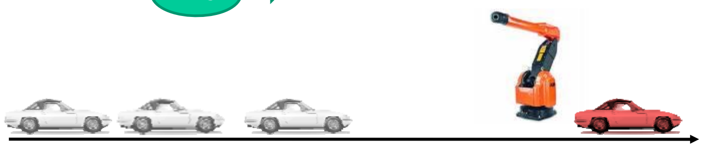
- Product-centric paradigm (Morel et al. 2003)
- The product is considered as an Information System (Tursi 2009)

Product-centric Paradigm

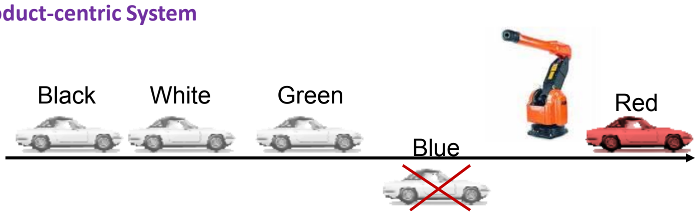
Painting Process Car Industry

1. **Fully integrated System**

MES ⇨ Colour Information : Red/Blue/Green/White/Black

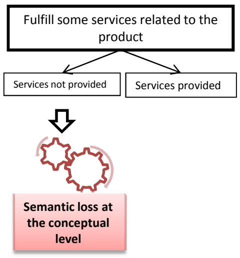


2. **Product-centric System**



Observations

- **Diversity of the semantics manipulated by the applications of the company**
- **Different exchange standards (ISO, IEC, CEN, BNAE)**
- **A technical and/or semantic incompleteness of the interoperation (vs. mission and /or requirements)**



Interoperability: The ability of two or more systems or elements to exchange information and to use the information that has been exchanged (IEEE 1990)

Interoperability relationship/interoperation: *Action to exchange the information by taking into account its semantics.*

Need to evaluate:
- **In one side the performance of the Information Systems vs. the company mission**
- **And in the other side the contribution of the interoperation on this performance.**

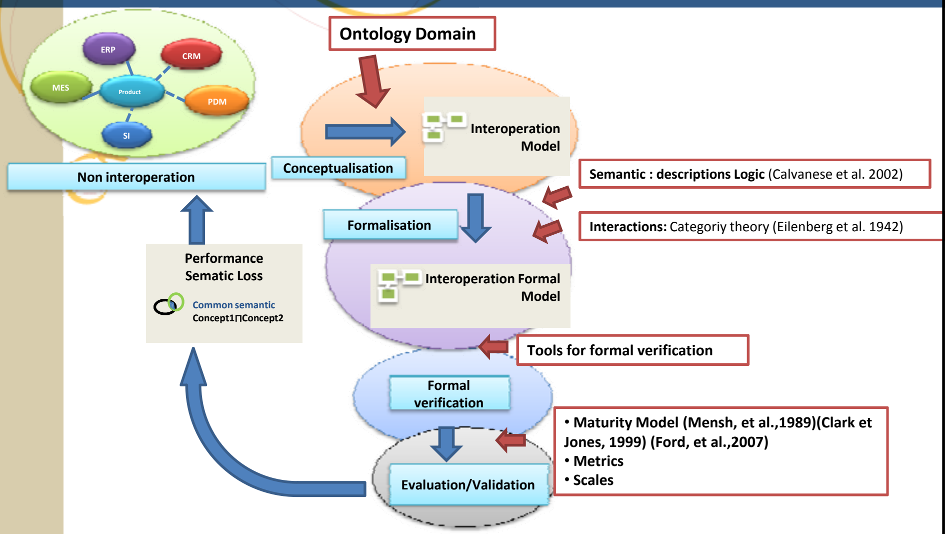
The main issue

Formalize and evaluate the interoperability property of a product-centric Information System

The objectives

- **Industrial objectives:** Improve the engineering process of the interoperability implementation for enterprise applications
- **Scientific objectives:** Contributions into the field of interoperability
  - Interoperability relationship evaluation
  - Formalize to understand the interoperability

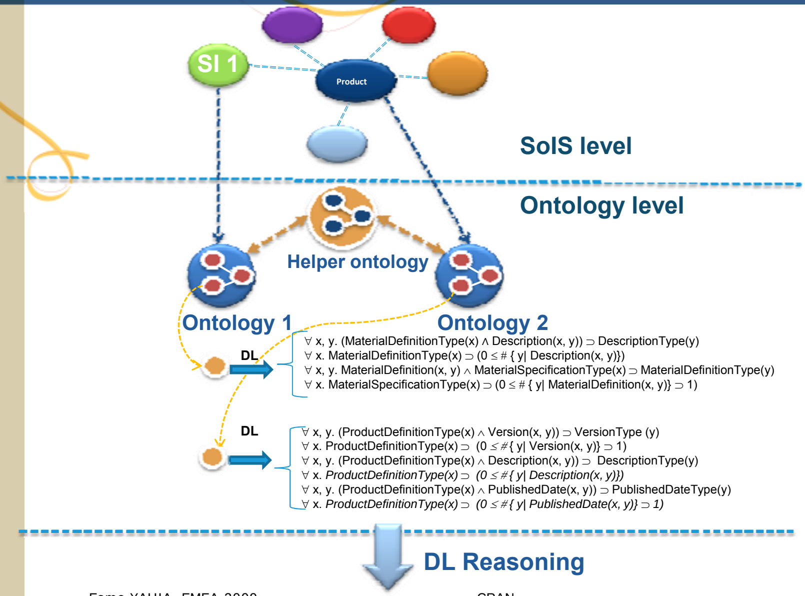
Proposed Approach



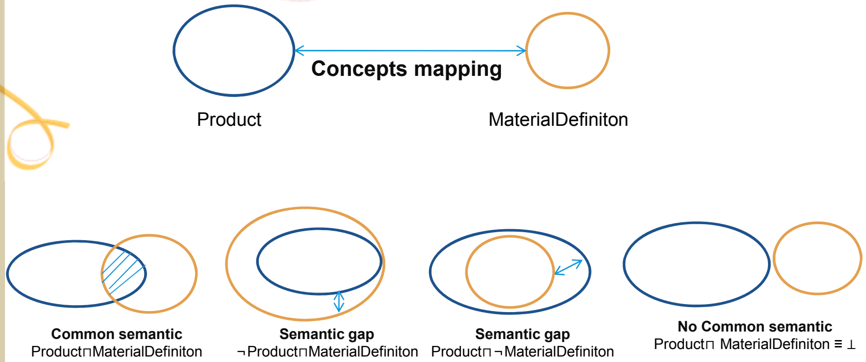
How to formalize the interoperability relationship?

- **We propose a methode to apply the mathematical tool Description Logic for the enterprise information system as a SoIS.**
- **We use Description logic to formalize the knowledge of information system applications.**
- **We use DL reasoner to detect the semantic gaps that may exist in two models with the applications around product.**

How to formalize the interoperability relationship?



Semantic Gap Definition



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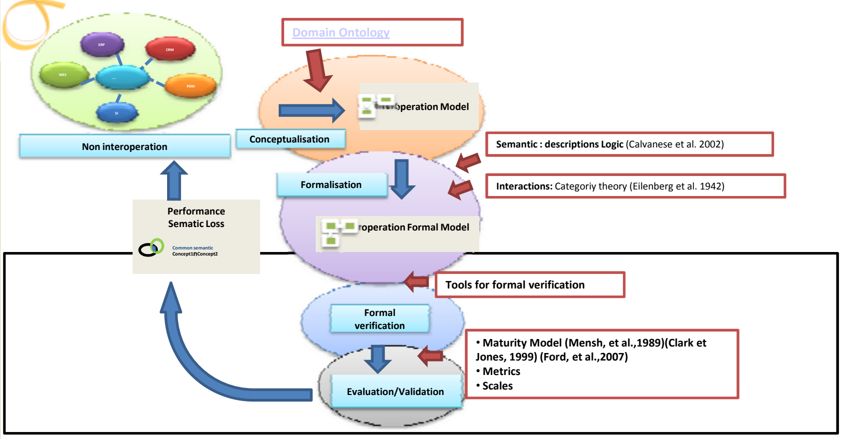
Futures work

- State of art of Category theory
- State of art of evaluation tools



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Thank you for your attention

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Ontology

- **An ontology is an explicit and formal specification of a shared conceptualization and provides a conceptual framework for communicating in a given application domain (Gruber,1993)**
- **Common components of ontologies include:**
  - **Individuals:** instances or objects
  - **Classes**: sets, collections, concepts, types of objects, or kinds of things.
  - **Attributes**: aspects, properties, features, characteristics, or parameters that objects (and classes) can have
  - **Relations**: ways in which classes and individuals can be related to one another
  - **Restrictions:** formally stated descriptions of what must be true in order for some assertion to be accepted as input
  - **Rules**: statements in the form of an if-then (antecedent-consequent) sentence that describe the logical inferences that can be drawn from an assertion in a particular form
  - **Axioms**: assertions (including rules) in a logical form that together comprise the overall theory that the ontology describes in its domain of application. This definition differs from that of "axioms" in generative grammar and formal logic. In those disciplines, axioms include only statements asserted as *a priori* knowledge. As used here, "axioms" also include the theory derived from axiomatic statements.
  - **Events**: the changing of attributes or relations
- **A domain ontology (or domain-specific ontology) models a specific domain, or part of the world. It represents the particular meanings of terms as they apply to that domain**

Description Logic

- **What is DL?**

  A family of knowledge representation (KR) formalisms that represent the knowledge of an application domain (the "world")
- **Features / Characteristics**
  - Decidable fragments of FOL – First Order Logic
  - Reasoning is a central service
- **A Description Logic - mainly characterized by a set of constructors that allow to build complex concepts and roles from atomic ones,**
  - Concepts correspond to classes / are interpreted as sets of objects
  - Roles correspond to relations / are interpreted as binary relations on objects
  - Individuals: instances

Description Logic

- **DL basics** (*ALC*)

Constructor	Syntax	Example	Semantics
atomic concept	A	Human	$A^I \subseteq \triangle^I$
atomic role	R	hasChild	$R^I \subseteq \triangle^I \times \triangle^I$
conjunction	$C \sqcap D$	Human ⊓ Male	$C^I \cap D^I$
disjunction	$C \sqcup D$	Doctor ⊔ Lawyer	$C^I \cup D^I$
negation	$\neg A$	¬ Male	$\triangle^I - A$
exists restr.	$\exists R.C$	∃ hasChild.Male	$\{x \mid \exists y. <x, y> \in R^I \wedge y \in C^I\}$
value restr.	$\forall R.C$	∀ hasChild.Male	$\{x \mid \forall y. <x, y> \in R^I \Rightarrow y \in C^I\}$

Reasoning example

- A simple subsumption reasoning

  vegan ≡ person ⊓ ∀ eats.plant
  vegetarian ≡ person ⊓ ∀eats.(plant ⊔ dairy)

  Based on these two definitions, is vegan subsumed by vegetarian (are all vegans vegetarians)?

  YES!!

  vegan ⊑ vegetarian

- Subsumption (D1 ⊑ D2)testing is the main operation of a DL reasoner

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