UNIVERSITEIT GENT

FACULTY OF ECONOMICS AND BUSINESS ADMINISTRATION

Towards Ontology-driven Information Systems: Redesign and Formalization of the REA-ontology

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Outline

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   - Case: REA business domain ontology
2. Reengineering Business Domain ontologies
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Business Domain Ontologies

Definition

A formal, explicit and shared specification of the concepts that are assumed to exist in the activity of providing goods and services involving financial, commercial and industrial aspects.

Applications

- support communication
- ontology-driven system development
  - Requirement elicitation
  - Modeling bussines application
- ontology-driven information systems:
  - decision support systems
  - e-collaboration systems

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Ontology-driven business modelling

Business Modelling Ontologies

Business Modelling ontologies are used to constrain the contents and structure of business models, thereby helping to identify and organize relevant objects, relationships and other knowledge.

Examples

- Toronto Virtual Enterprise (TOVE)
- The Enterprise ontology
- The Resource Event Agent enterprise ontology (REA)
- the e-Business Model Ontology (e-BMO)
- E^3 - value ontology

Ontology-driven information systems

Use of ontologies at run-time

Ontology-driven information systems can be used to create interoperability at different enterprise levels: shop-floor, intra-enterprise and inter-enterprise level.

Examples

- UNSPSC
- NAICS
- e-cl@ss classification and product description
- RosettaNet Technical Dictionary

Background and Motivation

Background

- use of business domain ontologies in practice is limited
- recently proposed business domain ontologies focused more on the theoretical background and content.
- areas for improvement for business domain ontologies:
  - development process
  - application-independence and reusability
  - representation of the ontology

Motivation

- success of applications depends in large extent on the quality of the conceptual backbone
- improving the ontology development process will also make the ontologies more useful outside the business modelling scope

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Research Goal

Global Research Goal:

Operationalization existing business domain ontologies

- improving quality business domain ontologies using existing ontology engineering techniques
- formalizing business domain ontologies
- improving usability of business domain ontologies
- evaluating and comparing business domain ontologies

Paper Research Goal:

Operationalization REA business domain ontology

- develop unified and consistent conceptual representation
- develop formal representation of the REA-ontology

REA-ontology

Characteristics

- origin: Resource Event Agent Accounting Model
- event-ontology: events occuring within the realm of a company, their participating agents, affected resources, and regulating policies.
- REA takes an intra-enterprise perspective

REA applications

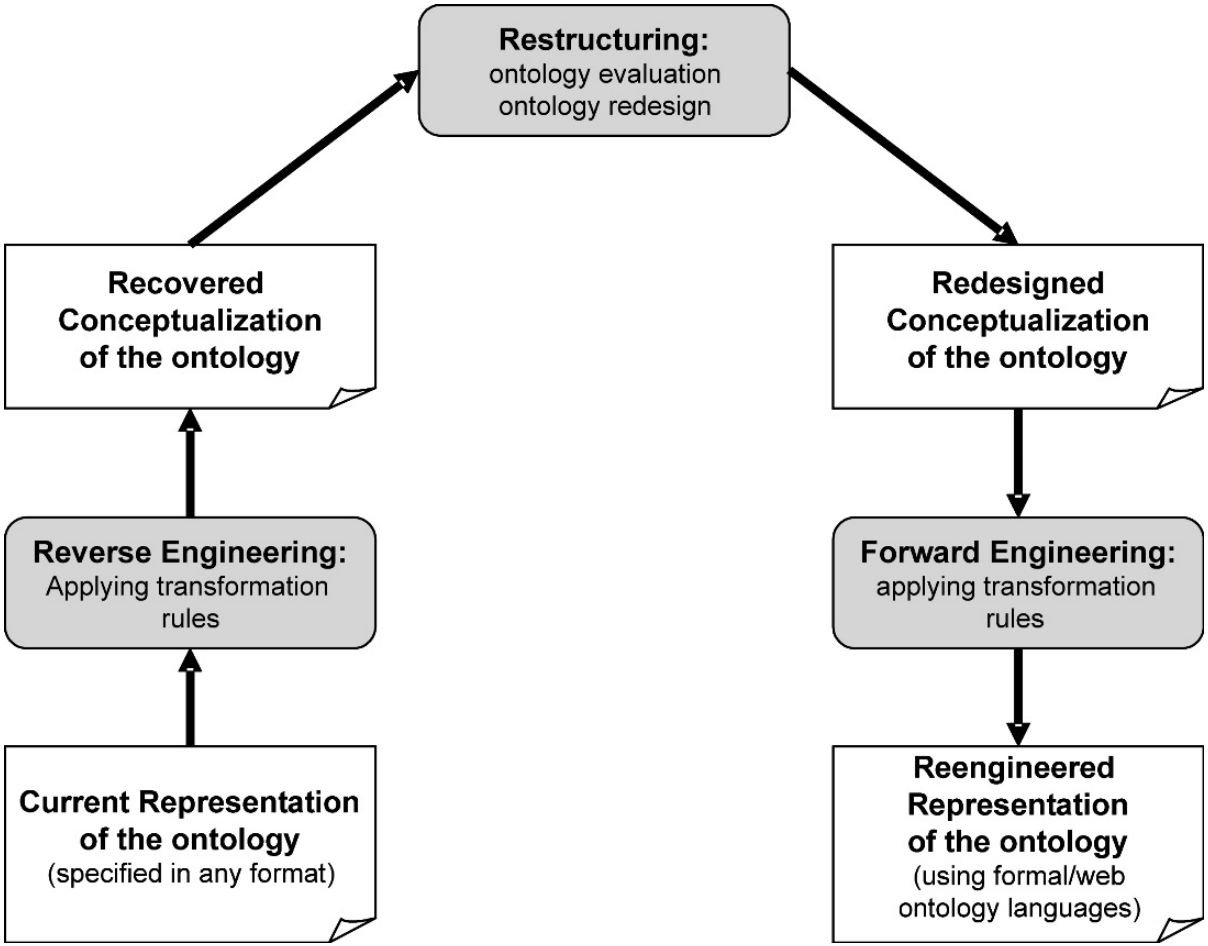
- conceptual data modelling
- design of accounting and operations management systems
- auditing and internal control
- e-collaboration

REA-ontology

Motivation

- shortcomings in the existent development process
  - a lot of confusion exists about the definitions of the concepts, the relations and the axioms
  - no complete formal representation
- remarkable increase in researchers' and practitioners' interest:
  - number of international standardization efforts for e-collaboration systems
  - REA has been proposed as a theoretical basis for the reference models that underlie ERP systems
  - part of recently proposed reference ontology for business models

A Business Domain Ontology Reengineering Methodology: overview



METHONTOLOGY Reengineering process

Definition

the process of retrieving and transforming a conceptual model of an existing and implemented ontology into a new, more correct and complete conceptual model which is reimplemented

Ontology reengineering phases:

- reverse engineering phase
- restructuring phase
  - analysis
  - synthesis
- forward engineering phase

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- forward engineering phase

Reengineerg the REA-ontology

- First iteration reengineering process
- From Lightweight Ontology to Formal ontology
- Focus on representation not on content REA-ontology
  - Redesign: Develop conceptual representation using UML class diagram
  - Formalizing: Develop formal representation in OWL using OMG's Ontology Definition Metamodel

Reverse Engineering the REA-ontology

Method

- the original non-formal representations are chosen as starting point for the reverse engineering
- REA literature sources were analysed for the 'manual' development of unified conceptualization which resulted in
  - concept tables
  - UML class diagram
  - three axioms

REA concept definitions at the business process level

Economic Resource

A thing that is scarce and has utility for economic agents and is something users of business applications want to plan, monitor and control.

Economic Event

A change in the value of economic resources that are under control of the enterprise.

Economic Agent

An individual or organization capable of having control over economic resources, and transferring or receiving the control to or from other individuals or organizations.

REA concept definitions at the business process level

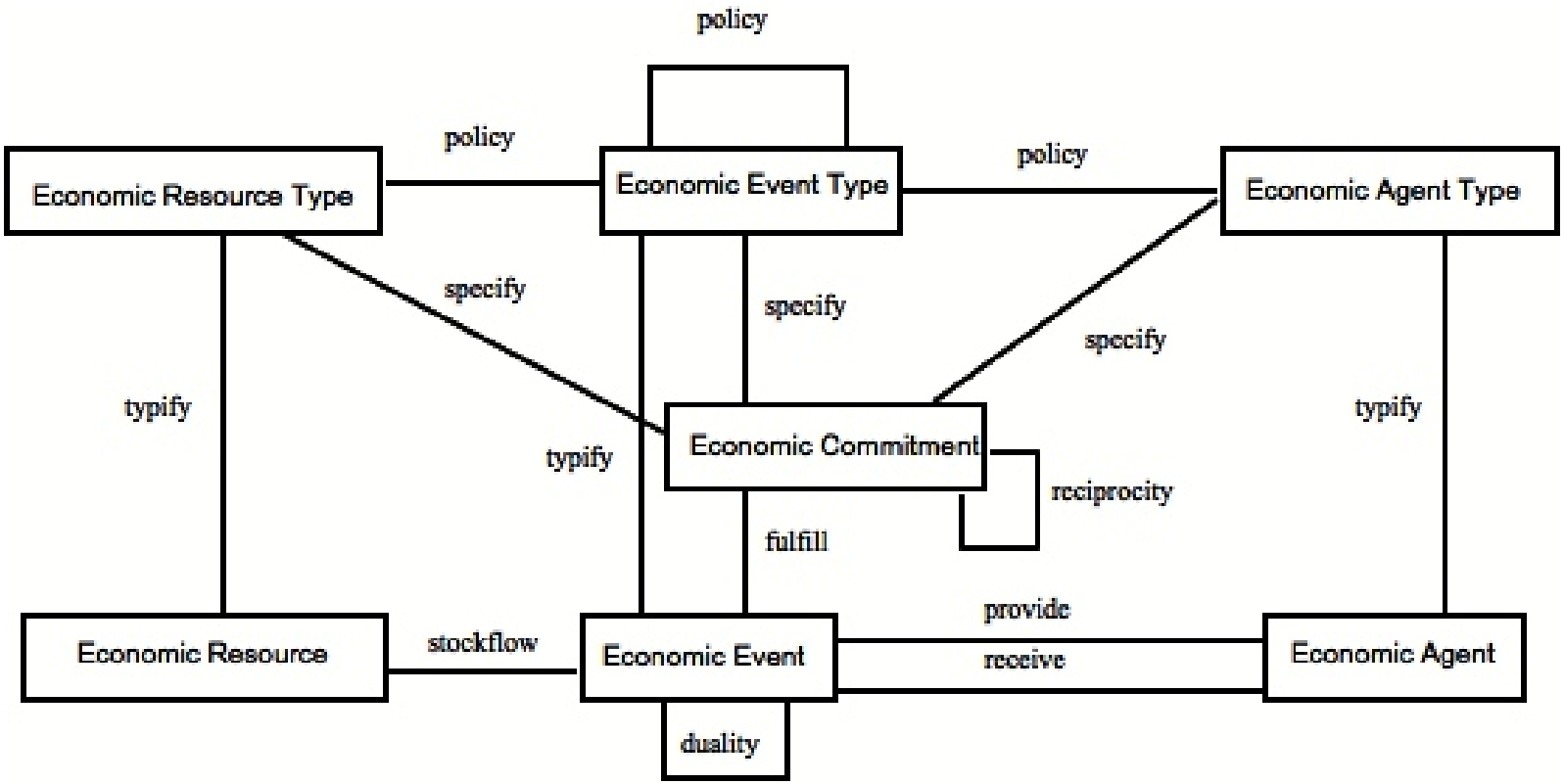
Commitment

A promise or obligation of economic agents to perform an economic event in the future

Contract

A collection of increment and decrement commitments and terms.

REA-ontology concept relations at the business process level



REA axioms

Axiom 1 :the stockflow axiom

At least one inflow event and one outflow event exist for each economic resource; conversely inflow and outflow events must affect identifiable resources.

Axiom 2 :the duality axiom

All events effecting an outflow must be eventually paired in duality relationships with events effecting an inflow and vice-versa.

Axiom 3 :the participation axiom

Each economic event needs to have at least one provide and a receive relationship with an economic agent.

Redesigning the REA-ontology

- redesign is based on the conceptual modelling and double articulation ontology engineering principles
- modifications:
  - specializations of classes and association classes (Increment Economic Event, Decrement Economic Event, ...)
  - representation of the basic axioms in the reengineered REA conceptualization
  - some originally proposed relations were left out because they are application specific

Redesign and Formalization of the REA-ontology

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Introduction

Reengineering Business Domain ontologies

Reengineering the REA-ontology

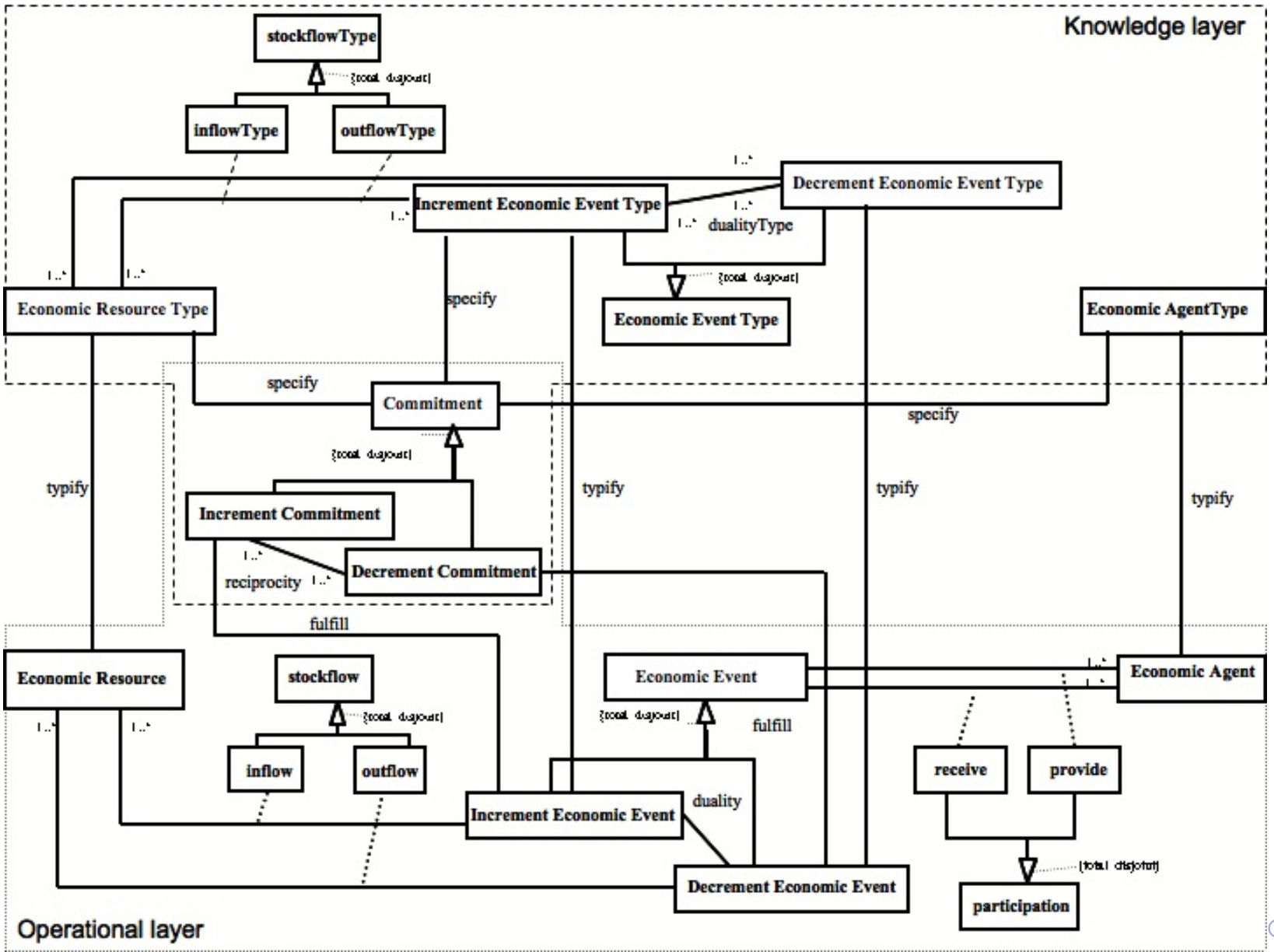
Reverse Engineering the REA-ontology

Redesigning the REA-ontology

Forward engineering the REA-ontology

Conclusions and Future Research

Ontology synthesis



Forward engineering

- formalization of the reengineered conceptualization uses recently adopted ODM (OMG)
- complete formalization can be downloaded from `http://users.ugent.be/~fgailly/REAontology/`
- the transformations are in most cases straightforward
- sometimes for the same UML construct different mappings rules can be used

UML class ⇒ Class, disjointWith

```
<owl:Class rdf:ID="Economic_Agent">
<owl:disjointWith
  rdf:resource="#Economic_Agent_Type"/>
<owl:disjointWith
  rdf:resource="#Economic_Event"/>
<owl:disjointWith
  rdf:resource="#Economic_Resource_Type"/>
<owl:disjointWith
  rdf:resource="#Economic_Resource"/>
<owl:disjointWith
  rdf:resource="#Economic_Event_Type"/>
<owl:disjointWith rdf:resource="#Commitment"/>
</owl:Class>
```

Binary association $\Rightarrow$ objectProperties, inverseOf

```
<owl:ObjectProperty rdf:ID="fulfill">
<rdfs:domain rdf:resource="#Economic_Event"/>
<rdfs:range rdf:resource="#Commitment"/>
<owl:inverseOf
     rdf:resource="#inverse_of_fulfill"/>
</owl:ObjectProperty>
<owl:ObjectProperty
       rdf:ID="inverse_of_fulfill">
<rdfs:domain rdf:resource="#Commitment"/>
<rdfs:range rdf:resource="#Economic_Event"/>
<owl:inverseOf rdf:resource="#fulfill"/>
</owl:ObjectProperty>
```

Total disjoint subclasses $\Rightarrow$ disjointWith, unionOf, subClassOf

```
<owl:Class rdf:ID="Economic_Event">
<rdfs:subClassOf>
<owl:Class>
<owl:unionOf rdf:parseType="Collection">
<owl:Class
  rdf:about="#Decrement_Economic_Event"/>
<owl:Class
   rdf:about="#Increment_Economic_Event"/>
</owl:unionOf>
</owl:Class>
</rdfs:subClassOf>
</owl:Class>
```

Total disjoint subclasses $\Rightarrow$ disjointWith, unionOf, subClassOf

```
<owl:Class rdf:ID="Decrement_Economic_Event">
<rdfs:subClassOf rdf:resource="#Economic_Event"
<owl:disjointWith
   rdf:resource="#Increment_Economic_Event"/>
</owl:Class>
<owl:Class rdf:ID="Increment_Economic_Event">
<rdfs:subClassOf
   rdf:resource="#Economic_Event"/>
<owl:disjointWith
   rdf:resource="#Decrement_Economic_Event"/>
</owl:Class>
```

UML multiplicities ⇒ minCardinality

```
<owl:Class rdf:ID="Increment_Economic_Event">
<rdfs:subClassOf>
<owl:Restriction>
<owl:onProperty
   rdf:resource="#inverse_of_inflow"/>
<owl:minCardinality
   rdf:datatype="&xsd;int">1
</owl:minCardinality>
</owl:Restriction>
</rdfs:subClassOf>
</owl:Class>
```

Conclusions

new conceptual representation of the REA-ontology

- uniform: using a single representation
- unified: including definitions of concepts, relations between concepts and axioms
- more useful for ontology-driven business modelling
  - understandable reference model for business modellers
  - meta-model for generating and validating business models

new OWL formalization of the REA-ontology

- can be used in practice for those wishing to explore the use of REA as a run-time ontology
- allows formal ontology evaluation

Future Research

Proposed methodology needs to be further elaborated

- content evaluation
  - ontological analysis using upper-level ontologies
  - applying existing ontology evaluation methods and tools
- the use of conceptual modelling languages for the conceptualization of the ontology
  - appropriateness of UML
  - use an OWL UML profile

Further investigate the use of business domain ontologies for

- ontology-driven business modelling
- demonstrate effectiveness and feasibility of using business domain ontologies for creating interoperability