Laboratory for Semantic Information Technology
Bamberg University

Ontology-based Verification of Core Model Conformity in Cadastral Modeling

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Agenda

1. Information Technology and Standardization
2. Conformity Verification for the Cadastral Domain
3. A Worked Example
4. Conclusions

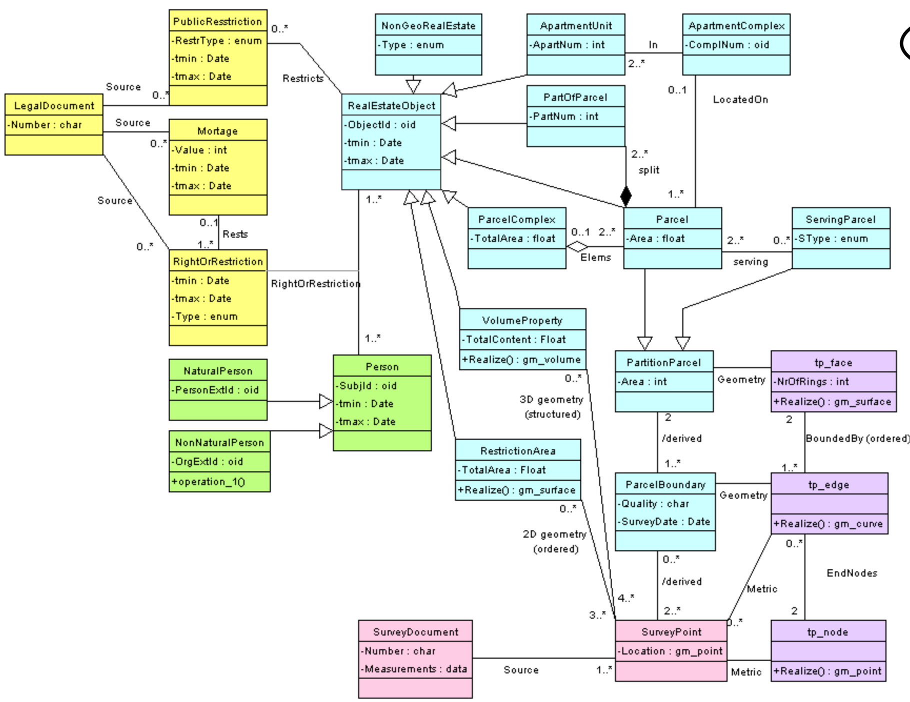
Information Technology

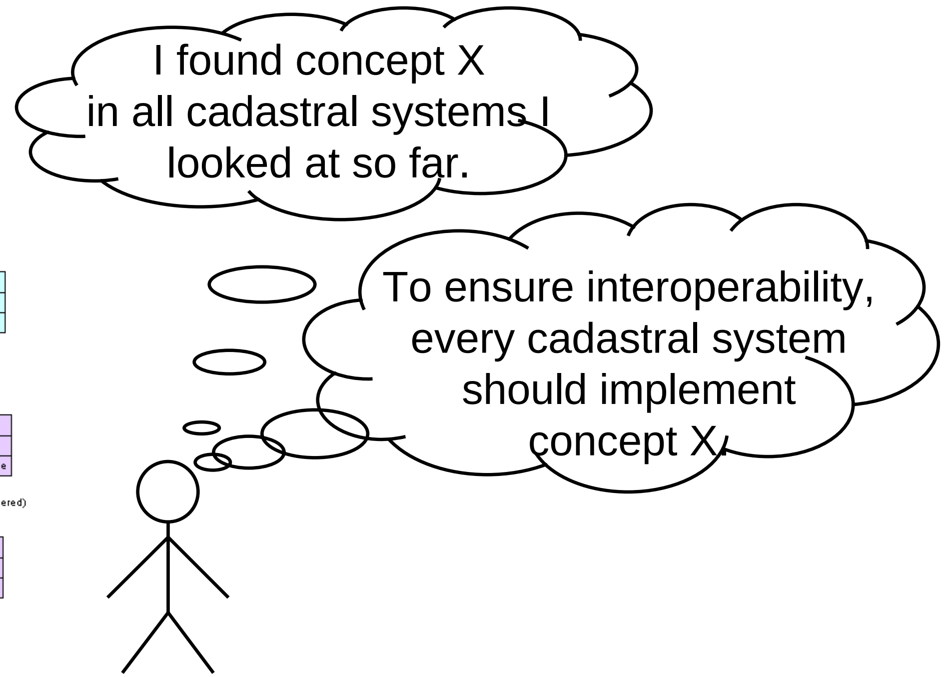
- Standard software for cadastral systems?
  - Currently, cadastral systems are custom-made technology
  - Standard software is state-of-the-art in other application domains: Enterprise Resource Planning (ERP) systems
  - ERP run worldwide despite differences in IT infrastructure, data and process models, national legislation
- Conformity verification
  - Technology that supports data and process modeling
  - Basis for cadastral systems as customizable standard software

Cadastral Standardization

- A common misunderstanding
  - Standardization does NOT aim at having a single cadastral system running in all countries.
  - The purpose of standardization consists in identifying common structures in cadastral data and process models
  - and to exploit them for building software components for customizable standard software
- Data and process modeling
  - Development of a core cadastral data and process model
  - National models as extensions of the core cadastral model

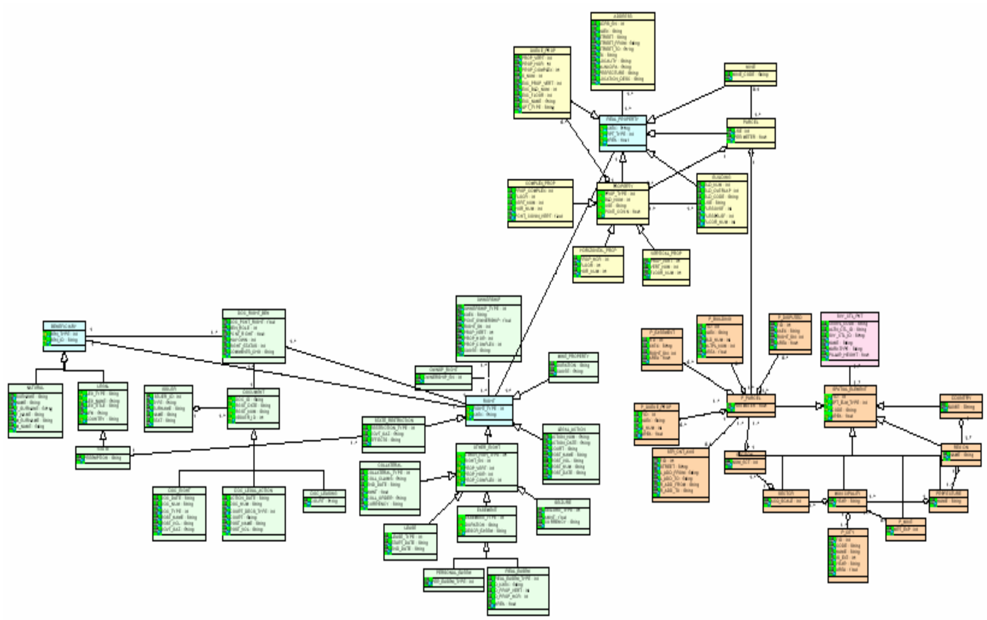
Core Cadastral Domain Model

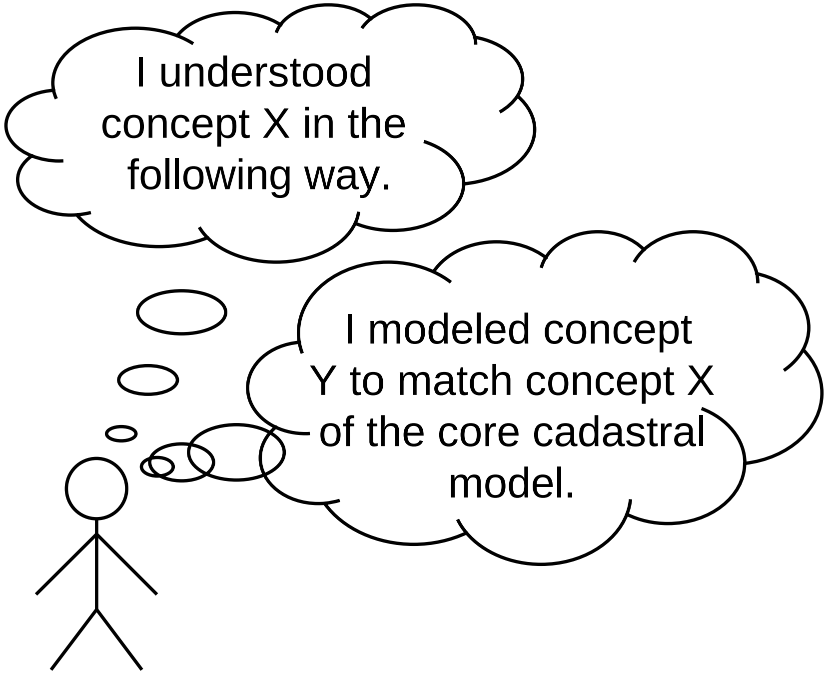




Core Modeler (TU Delft, ITC)

Greek Cadastral Model



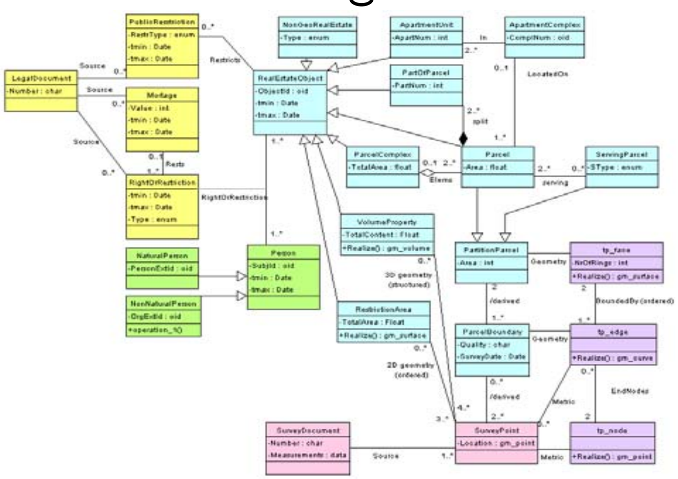


Domain Modeler
(Greek Cadastre)

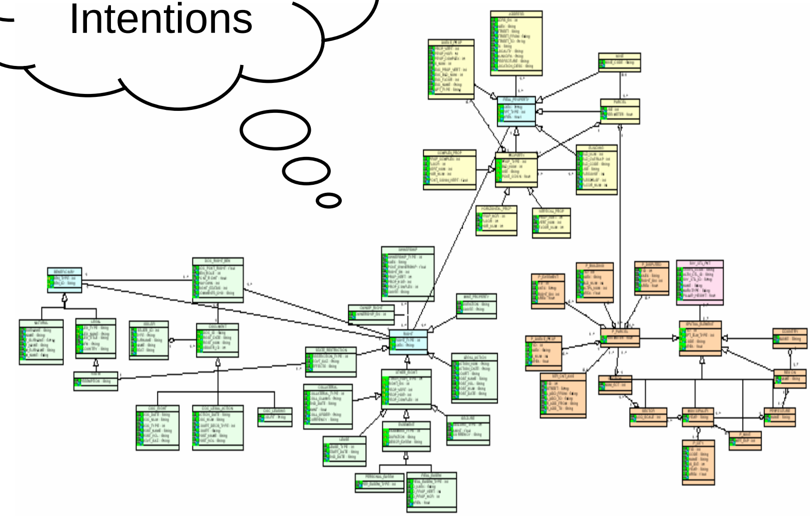
Conformity Verification

Conformity Intentions

Modeling Intentions



Core Model



Domain Model

CCC

Conceptual Conformity Checker

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Iterative Modeling Process

Core Model:
Formalization of
Conformity Intentions

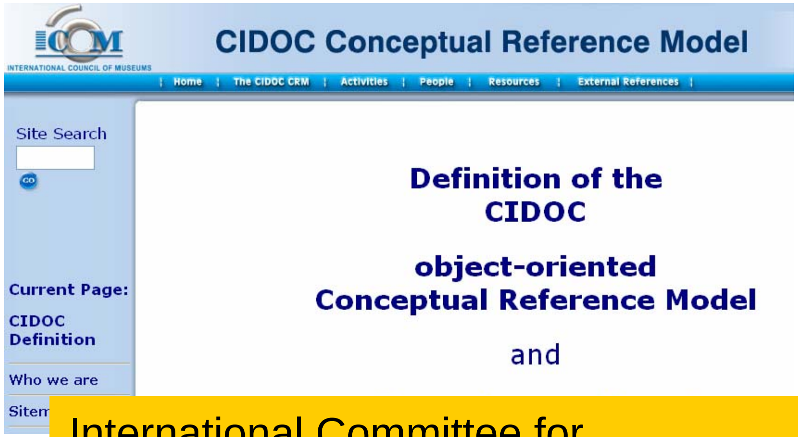
Domain Model:
Formalization of
Modeling Intentions

Reasoning support by CCC:
- Necessary Modifications
- Inconsistencies
- Satisfaction of Constraints

Conformity

Data Modeling Technologies

- Technology generations
  - Entity-Relationship Models
  - Object-oriented Modeling (UML and literate UML)
  - Ontological Modeling
- Ontological modeling?
  - Enhanced expressiveness
  - Reasoning support



International Committee for Documentation of the International Council of Museums (ICOM-CIDOC)

1994	Entity relationship model
2002	Object-oriented model
2004	Formal ontological model

Ontological Modeling

XMI + text

```
<UML:Class xmi.id = 'a15' name = 'Person'
      visibility = 'public' isSpecification = 'false'
      isRoot = 'false' isLeaf = 'false' isAbstract
      = 'false' isActive = 'false'>
      …
      <UML:Attribute xmi.id = 'a373' name =
      'tmin' visibility = 'private' isSpecification =
      'false, ownerScope = 'instance'>
            …
      </UML:Attribute>
      …
</UML:Class>
```

"Each *Person* is either a *NaturalPerson* or a *NonNaturalPerson*. No Person can be a *NaturalPerson* and a *NonNaturalPerson*."

OIL

```
<daml:Class rdf:about="#Person“ rdfs:label="Person">
      …
   <daml:Restriction>
      <daml:onProperty>
        <daml:DatatypeProperty
                rdf:about="#Person_tmin"/>
      </daml:onProperty>
      <daml:hasClass rdf:resource="http://
       www.w3.org/2000/10/XMLSchema #date"/>
  </daml:Restriction>
  <daml:disjointUnionOf rdf:parseType=
                "daml:collection">
      <daml:Class rdf:about="#NaturalPerson"/>
      <daml:Class rdf:about="#NonNaturalPerson"/>
  </daml:disjointUnionOf>
</daml:Class>
```

Generic Mapping Relations

- Modeling workflow
  - Correspondences are identified by domain experts
  - Small set of generic mapping relations
- Correspondences
  - Classes
  - Attributes
  - Classes and attributes
- Heterogeneity problems
  - Structural heterogeneity: Semantically equivalent information is stored in different data structures
  - Semantic heterogeneity: Different interpretation of syntactically the same information

Correspondence in OIL

- Correspondence between attributes: daml:samePropertyAs

```
<daml:ObjectProperty
        rdf:about="core_cad.daml#Person_SubjID"
        rdfs:label="Person_SubjID">
  <daml:domain rdf:resource="core_cad.daml#Person"/>
  <daml:range rdf:resource="core_cad.daml#oid"/>
  <daml:samePropertyAs rdf:resource=
        "#Greek_cad.daml#BENEFICIARY_BEN_ID"/>
</daml:ObjectProperty>
```

Types of Correspondence

- Reasoner
  - determines type of the identified correspondence by ontological reasoning
- Types
  - Equivalence
  - Subsumption
  - Overlapping
- Special Cases
  - Restriction of the range of an attribute
  - Co-extensional concepts without corresponding attributes
  - Corresponding packages

Query and Interpretation

Type	Query to RACER
Equivalence	concept-equivalent?
Subsumption	concept-subsumes?
Overlapping	Create new class + concept-satisfiable?

- Example:

  (concept-equivalent? |core_cad.daml#Person||Greek_cad.daml#BENEFICIARY|);

  …
- Result: True or false
- Interpretation: The classes Person and BENEFICIARY are, according to the identified correspondences, overlapping.
- Is this type of correspondence sufficient?

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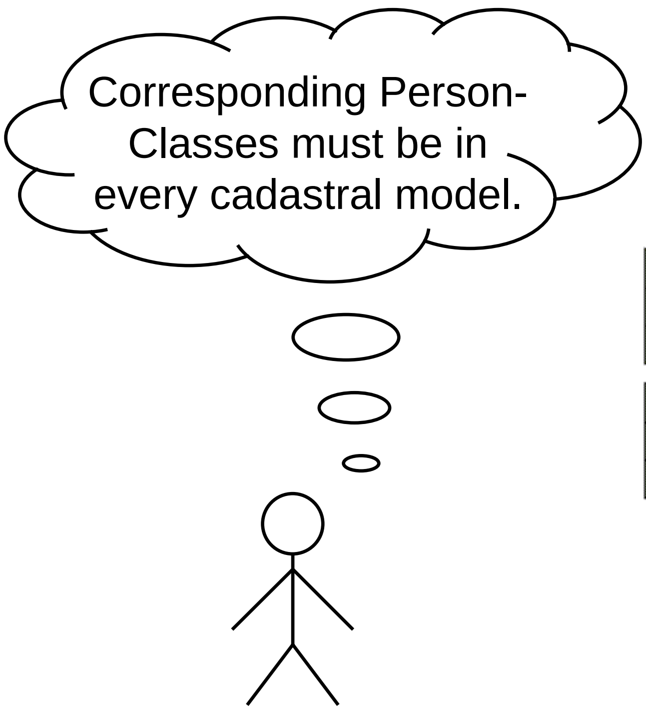
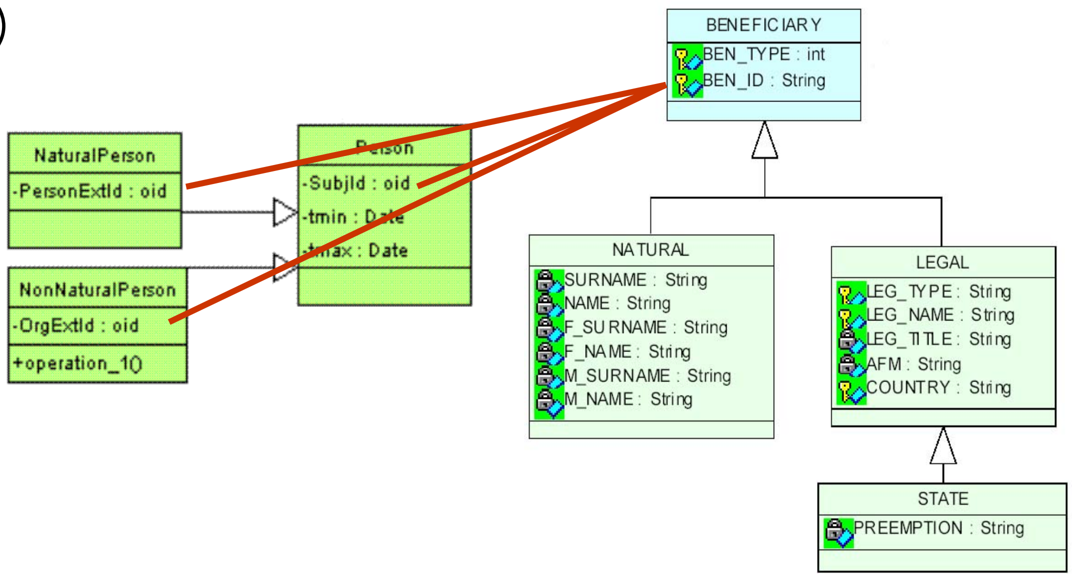
1st Iteration: “Person”-Classes



Core Modeler



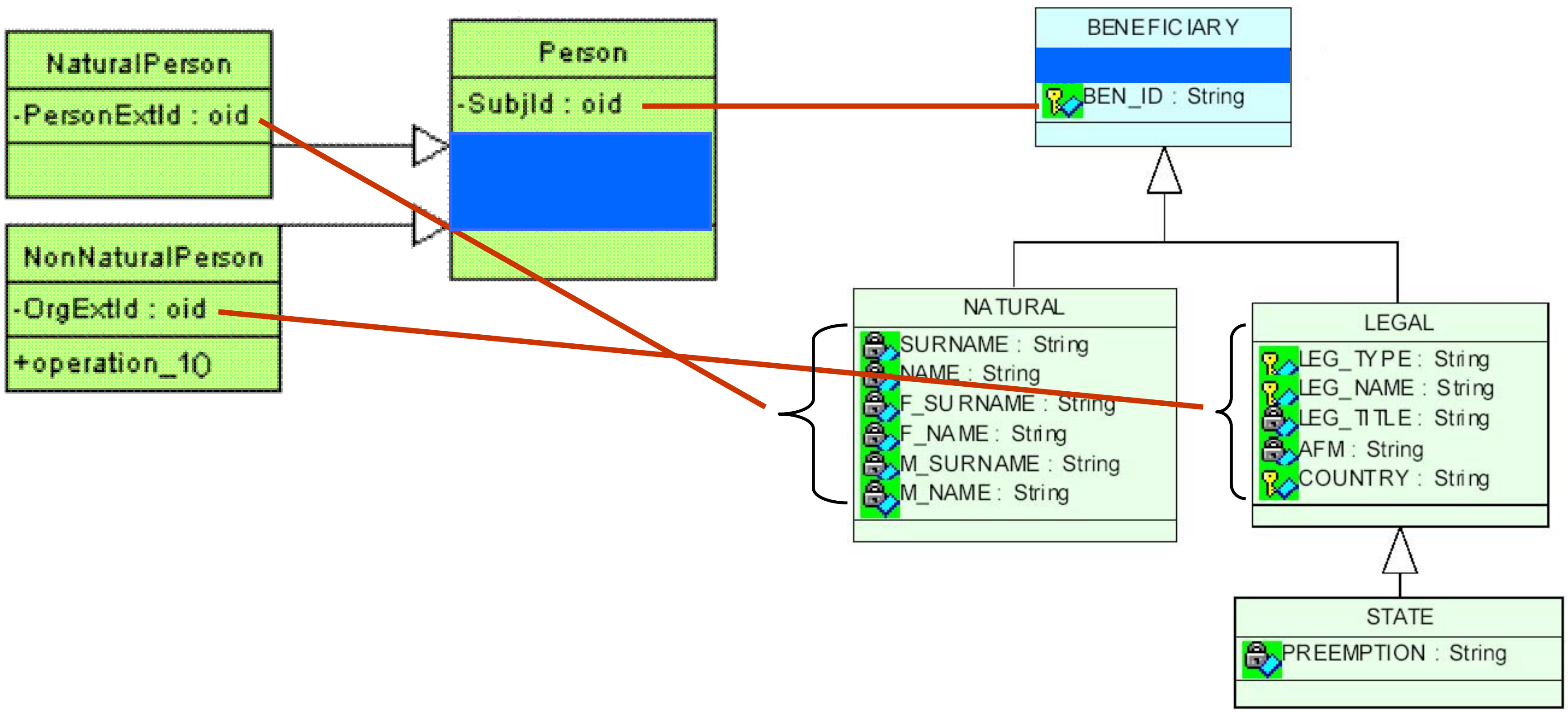
Core Model

Greek Model

1st Iteration: Results of the Reasoner

- Correspondences only of the overlapping type:
  - Person – BENEFICIARY
  - NaturalPerson – BENEFICIARY
  - NonNaturalPerson – BENEFICIARY
- No relation between the specialization classes
- No corresponding attribute for
  - t_min and t_max (class Person)
  - BEN_TYPE (class BENEFICIARY)

2nd Iteration: Proposed Modifications



Core Model

Greek Model

2nd Iteration: Results of the Reasoner

- Person and BENEFICIARY are equivalent
  - Temporal aspects must be either added to the class BENEFICIARY or omitted in the class Person!
- Equivalence between the specialization classes:
  - NaturalPerson equivalent with NATURAL,
  - NonNaturalPerson equivalent with LEGAL.

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First results

- Evaluation of the example
  - Poor results of the first iteration due to the limited number of formalized correspondences
  - First iteration provides advice for the subsequent iteration
  - Results of the 2nd iteration must be evaluated by domain experts
- Next steps
  - Refinement of the correspondences between core and Greek cadastral model
  - 2nd iteration with all refined correspondences
  - Elaboration of the attribute-level of core and domain models

Conclusions

- Improved conformity between the models
  - Resoner results provide useful advice for subsequent iterations
  - Iterative refinement of the correspondences
- Difficulties in the models are revealed
  - Need for discussing core and domain models
  - Core and domain models at the same level of abstraction
- Conforming models as basis for new applications
  - Exchange of cadastral data
  - Development of customizable standard software
- Future research
  - Conformity verification is not restricted to the cadastral domain
  - Extension of the conformity verification to process models