Laboratory for Semantic Information Technology
Bamberg University

Ontology-based Verification of Core Model Conformity in Cadastral Modeling

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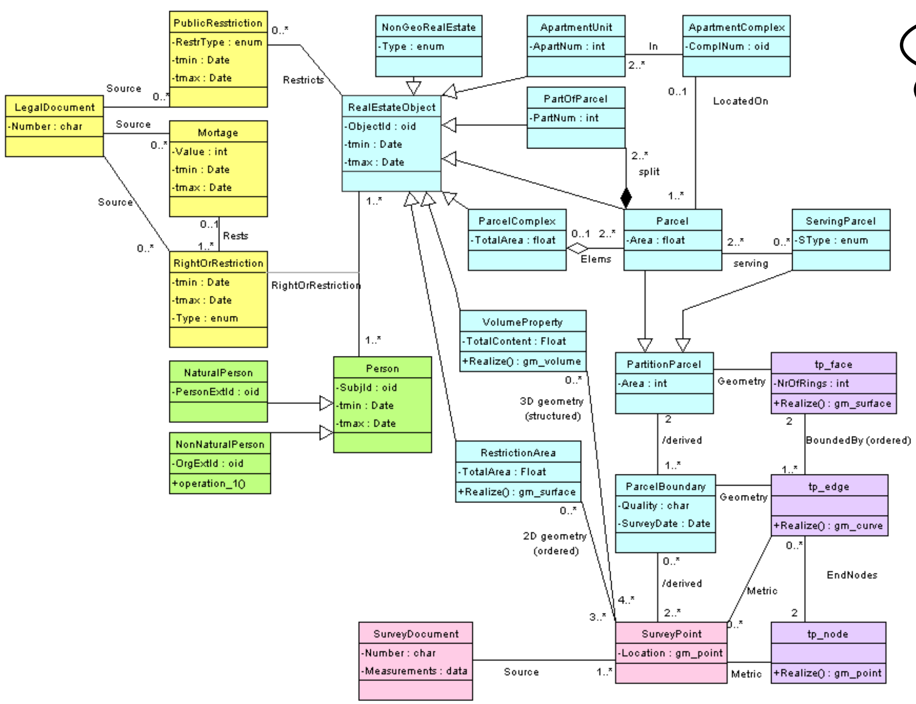
Agenda

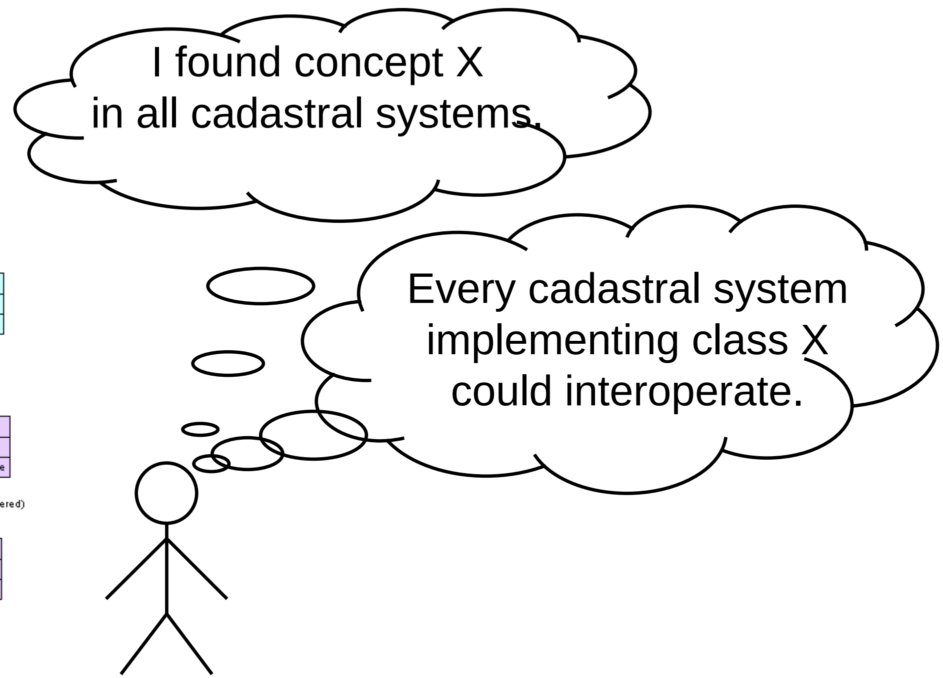
1. **Motivation**
2. Approach
3. Prototype
4. Future Research

Approach in the context of COST Action G9

- Standardization in the cadastral domain
  - Not one single cadastral system running in all European countries
  - But: Conforming national cadastral models
  - Development of a core cadastral data and process model
  - National models as extensions of the core cadastral model
- Advantages:
  - Interoperability
  - Software development and reuse

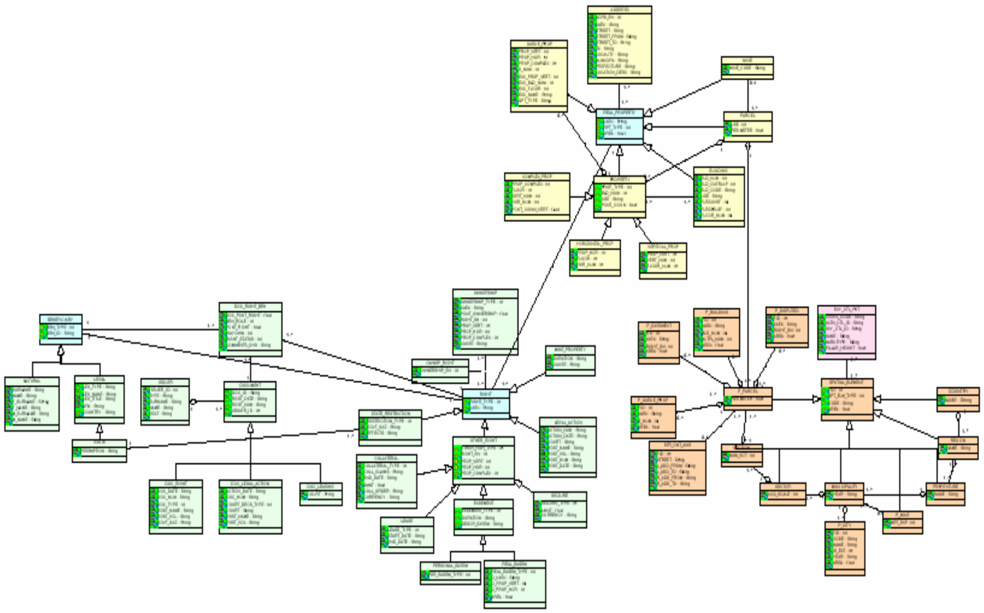
Core Cadastral Domain Model

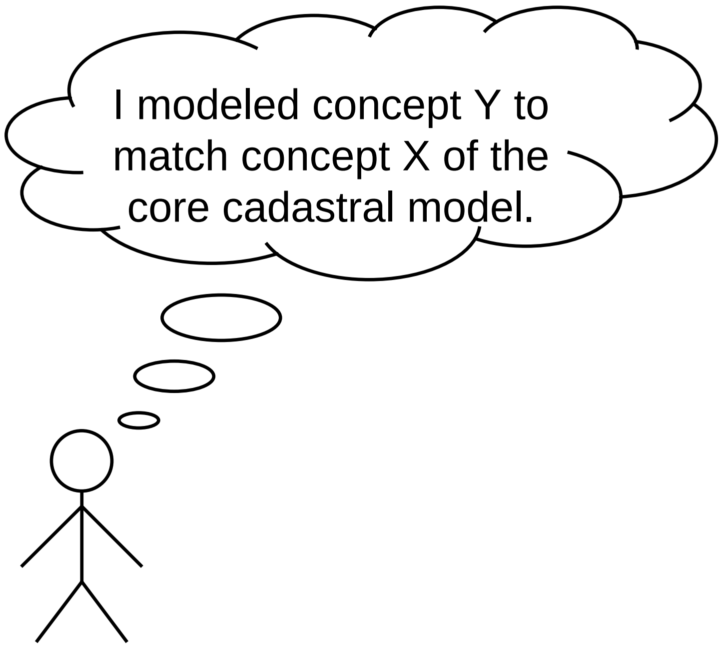




Core Modeler

Greek Cadastral Model



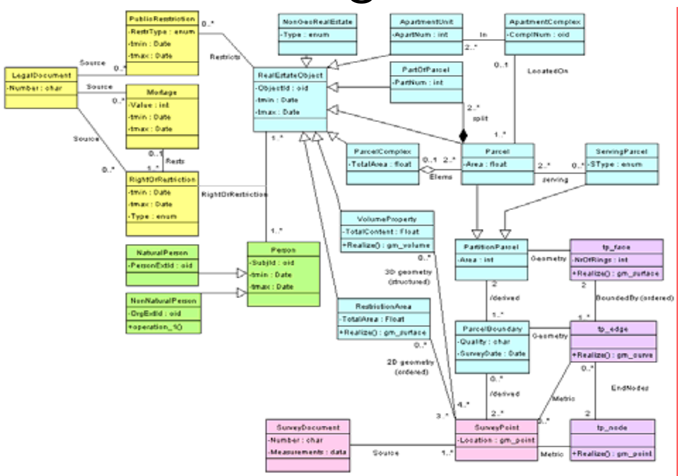


Modeler Greek Cadastre

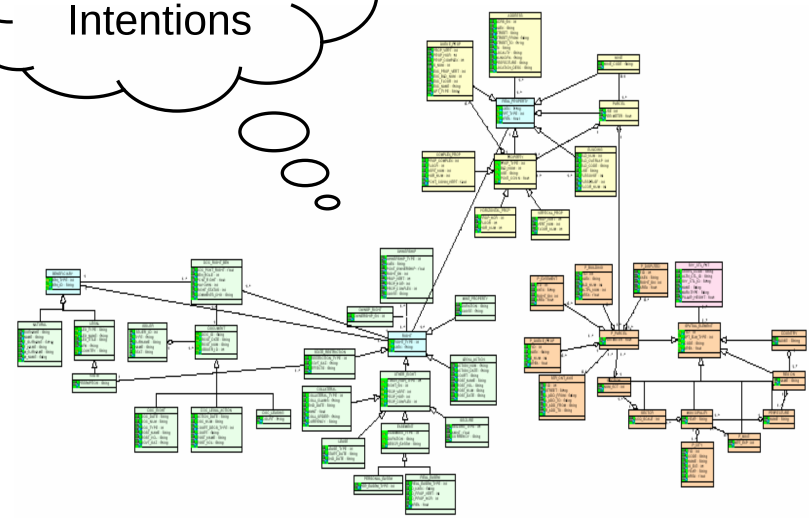
Conformity Verification

Conformity Intentions

Modeling Intentions



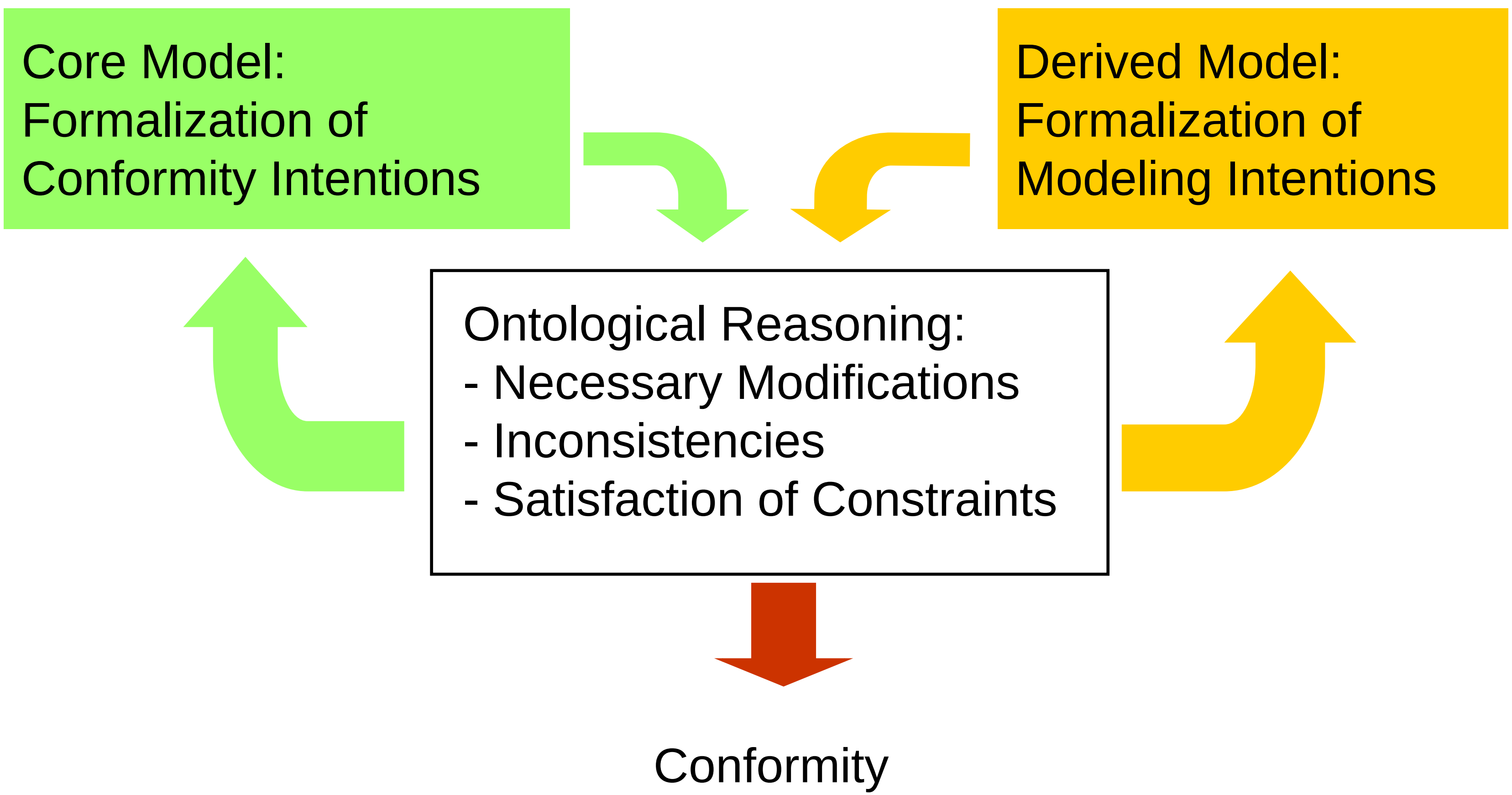
Core Model



Supposedly Derived Model

?

Iterative Modeling Process



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“Ontology-based Verification of Core Model Conformity in Conceptual Modeling”

- Conceptual Models
  - UML class diagrams
  - Textual constraints of Literate UML
- Enhanced expressiveness of ontological modeling
- Reasoning about ontologies
  - Computes the type of a relation between concepts
    - Indicator for the “strength” of the relation
    - Formal verification of the domain experts intentions
  - Detects inconsistencies in and across core and derived models

Transformation UML → OIL

- XMI

```
<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>
```

- Literate UML

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

- DAML+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>
```

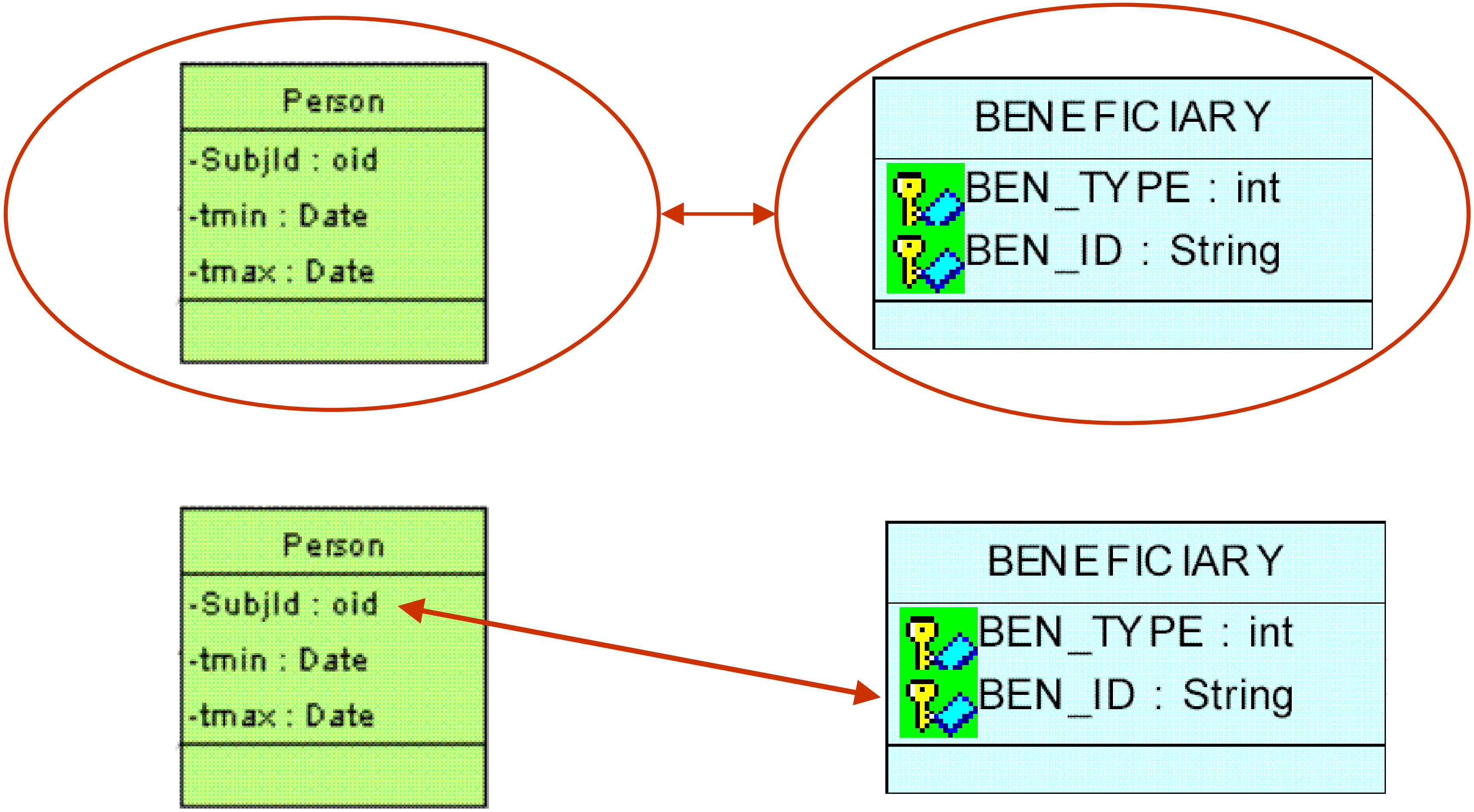
Conformity Constraints

- Conformity Constraints: Set of classes and attributes of the core model which must have a corresponding element in the derived model
- Define the minimum of required “similarity” between core and derived models

Generic Mapping Relations

- Correspondences are identified by domain experts
- Small set of generic mapping relations
- Correspondences are identified between
  - 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

Example: *Person* - *Beneficiary*



Correspondence in DAML+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
  - Approximate Mapping
- 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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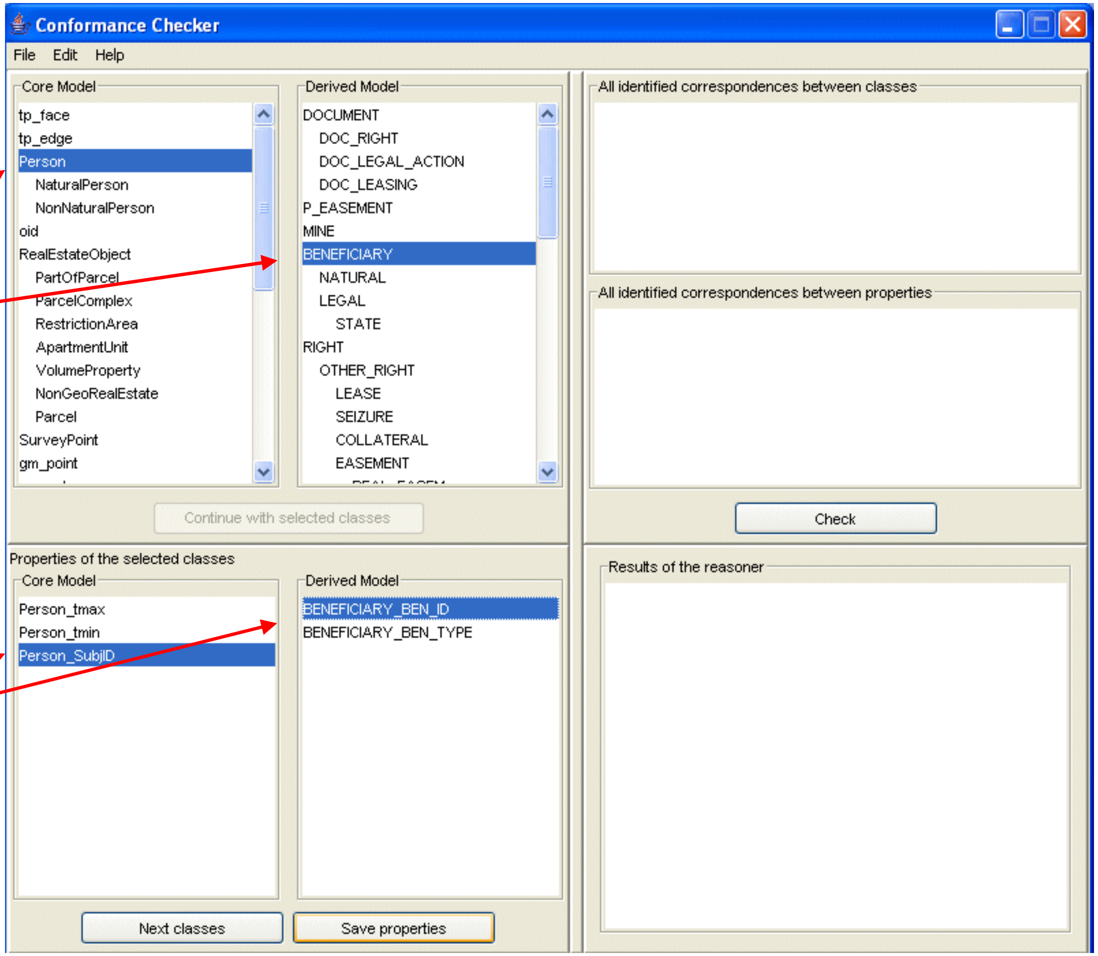
Prototype (1/2)

- Demonstrates the feasibility of applying the theoretical approach
- Most important features of the theoretical approach are realized
- Verification of conformity between
  - Core cadastral domain model and
  - Greek cadastral model

Prototype (2/2)

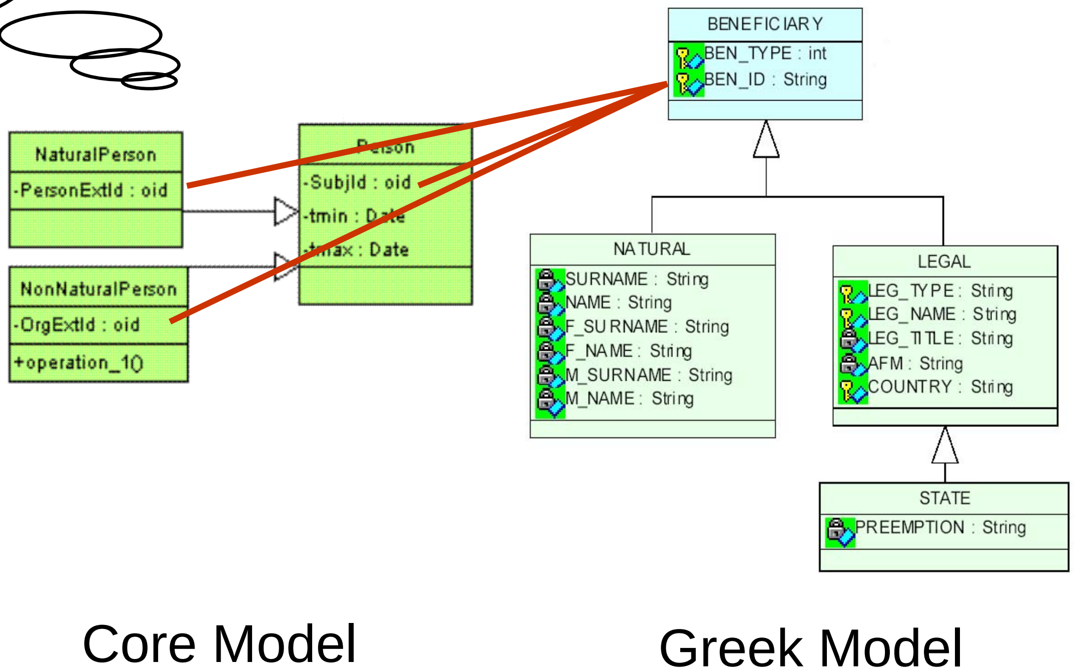


Correspondence between classes

Correspondence between attributes

"Person"-Classes: 1st Iteration

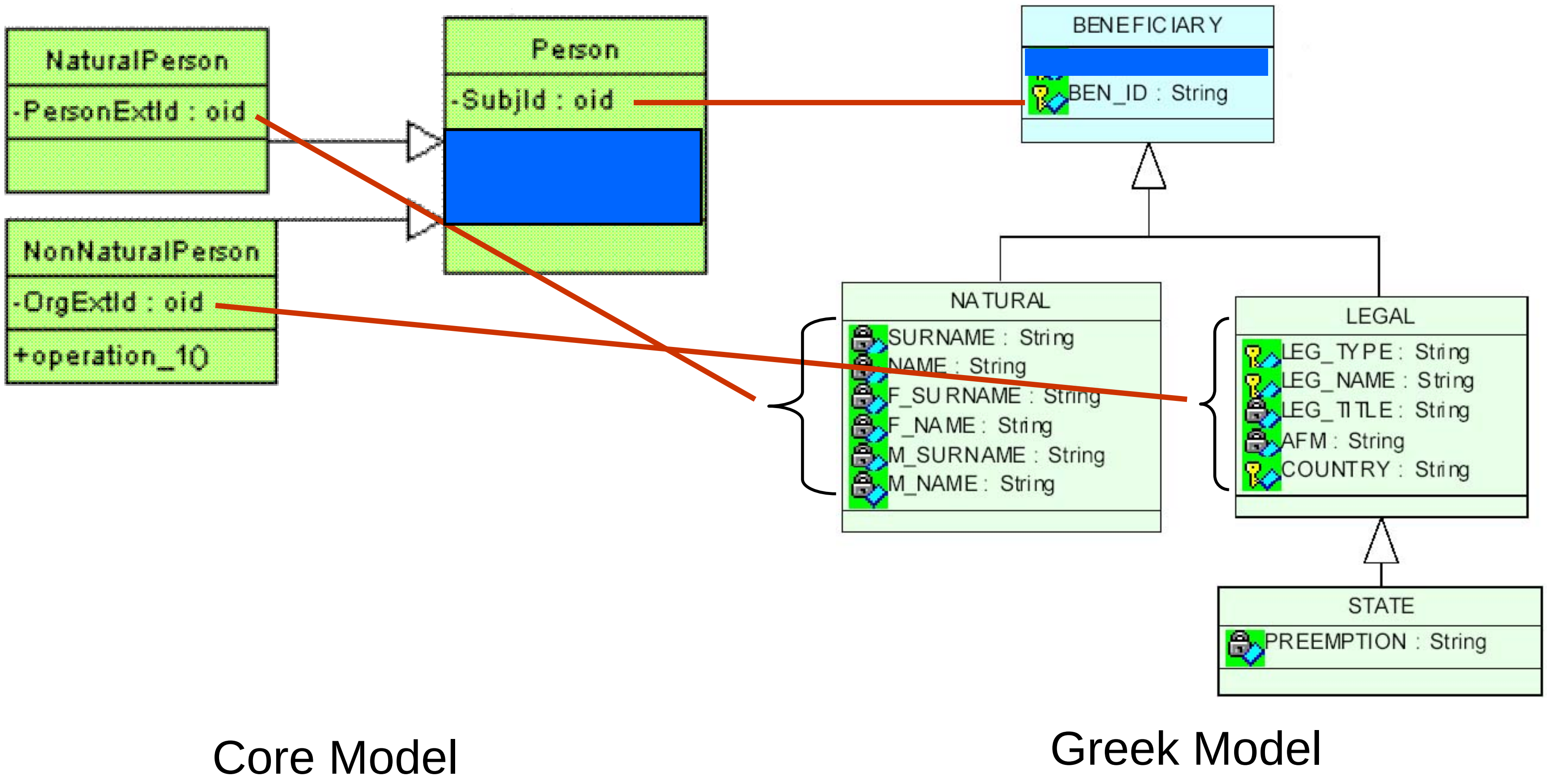
Equivalent Person-Classes must be in every cadastral model!



Results of the 1st Iteration

- 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)
- No corresponding attribute for BEN_TYPE (class BENEFICIARY)

Proposed Modifications: 2nd Iteration



Results of the 2^{nd} Iteration

- 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.

Evaluation

- 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 step:
  - Refinement of the correspondences between core and Greek cadastral model
  - 2nd iteration with all refined correspondences
  - Elaboration of the attribute-level of core and derived models

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Future Research in the Conformity Verification

- Refinement of the types of relations:
  - For concepts: complementOf, …
  - For attributes: inverseOf, subPropertyOf
- More detailed examination of inconsistencies
- Extension of the conformity verification to process models