Logic-based reasoning support for Semantic Business Vocabulary and Rules

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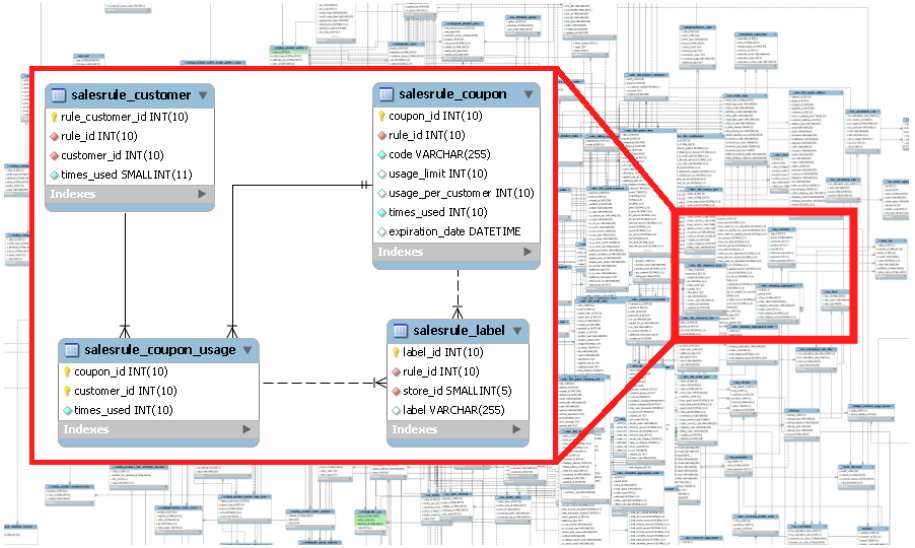
Motivation: Business Models - Need for Automation

- Business models may explode in size and become incomprehensible, e.g. like in *Magento eCommerce*.
- The Semantics of Business Vocabulary and Business Rules standard allows to model rules using Structured English:

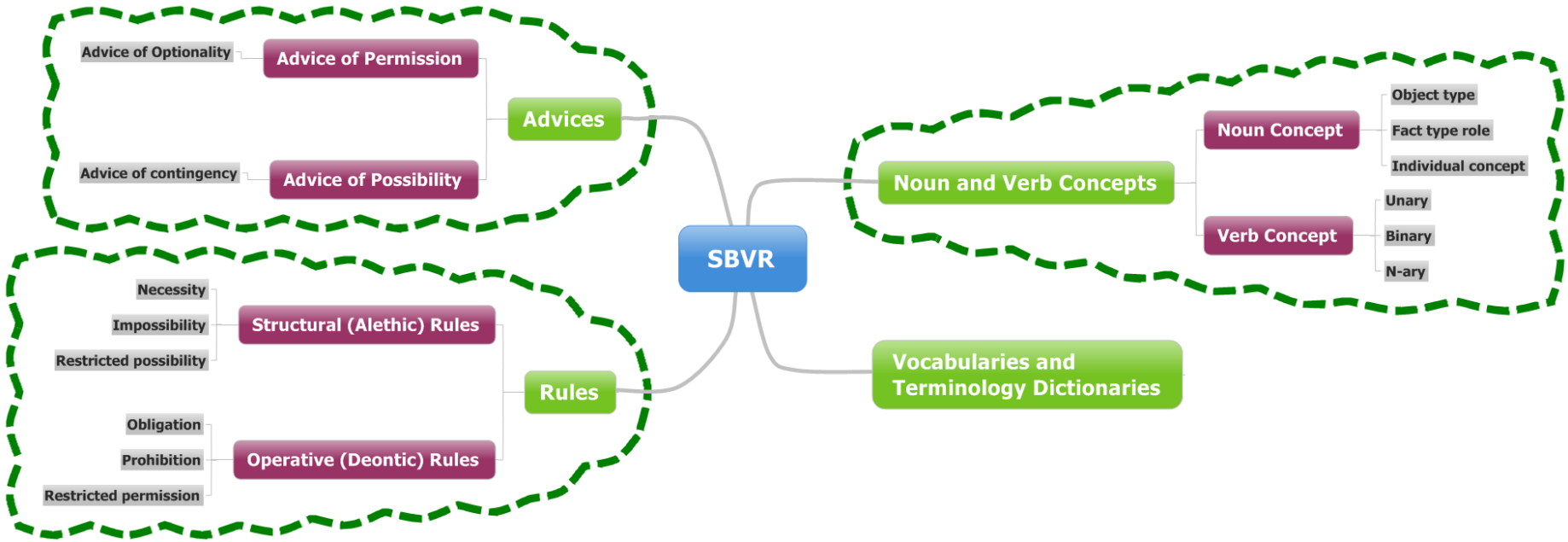


Each invoice *includes* at most one coupon.

***It is obligatory that* each coupon usage *is validated*.**

- No existing modeling approach enables automated reasoning about business rules.

Semantics of Business Vocabulary and Business Rules (SBVR)



- Provides means for specifying business rules in natural language.
- Defines two types of business rules: structural and behavioural.
- Adopts ORM2 and CogNIAM graphical notations.

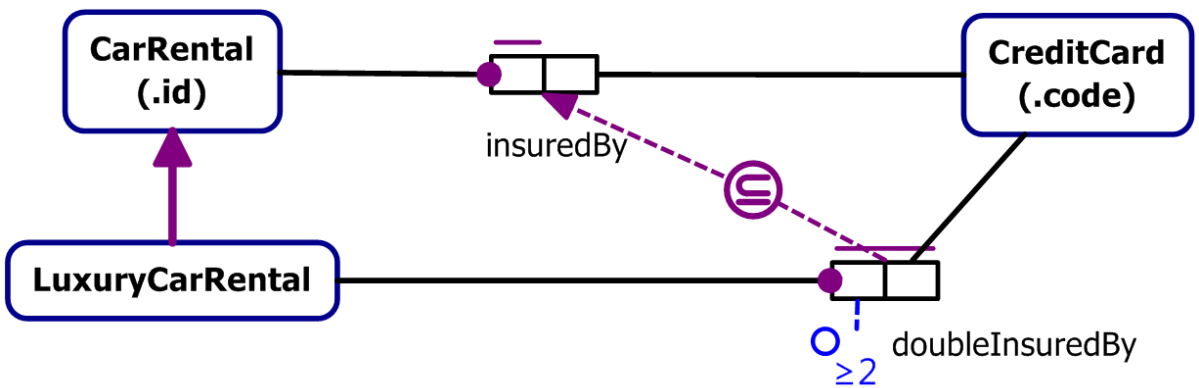
Problem

- Merging business models (e.g. A and B) may lead to conflicting rules:

  (R_1^A) **Each car rental *is insured by* exactly one credit card.**

  (R_1^B) **Each luxury car rental *is* a car rental.**

  (R_2^B) **It is obligatory that each luxury car rental *is insured by* at least two credit cards.**



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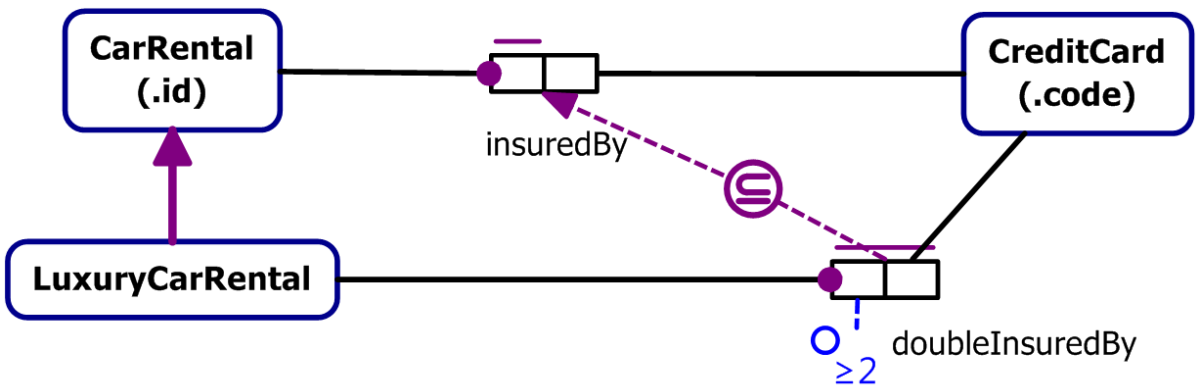


- No underlying logical formalism — no SBVR reasoner.
- **Our solution is to define a logical formalization of SBVR and provide a reasoning support on top of it.**

Logic for Formalization of SBVR

- We introduce first-order deontic-alethic logic (FODAL) – multimodal predicate logic with complete and sound axiomatization.
- Fully captures the desired semantics of business rules:

$(\tilde{R}_1^A)$ $\Box(\forall x \exists^1 y(CarRental(x) \wedge Insured(x,y)))$

$(\tilde{R}_1^B)$ $\Box(\forall x(LuxuryCarRental(x) \rightarrow CarRental(x)))$

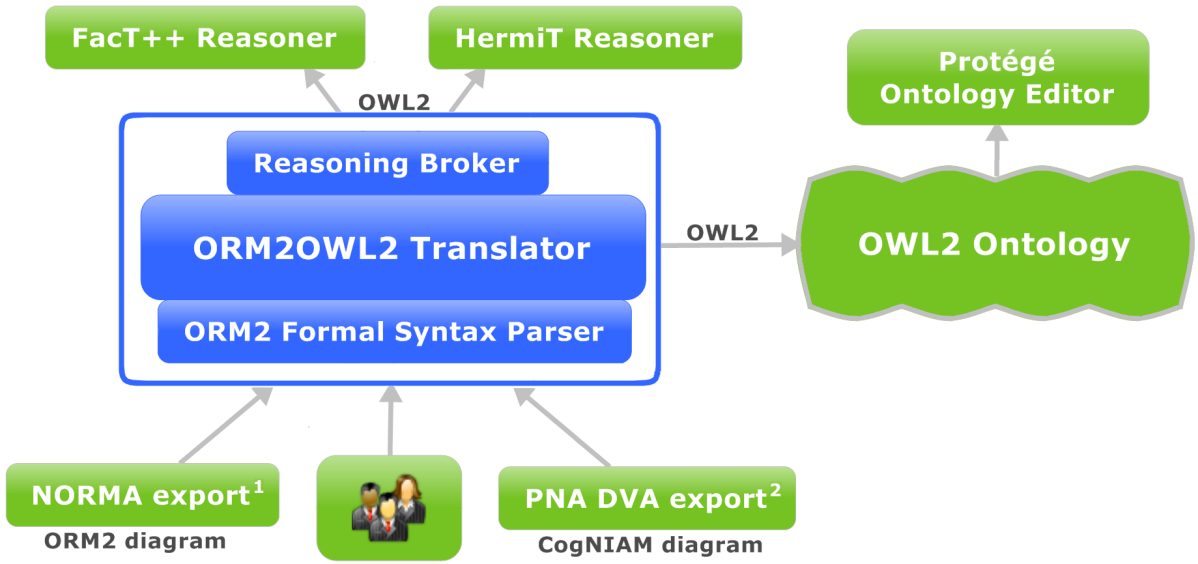
$(\tilde{R}_2^B)$ $\boldsymbol{O}(\forall x \exists^{\geq 2} y(LuxuryCarRental(x) \wedge Insured(x,y)))$

- Axiom allowing for interaction of modalities: $\Box(\phi(x)) \rightarrow \boldsymbol{O}(\phi(x))$.

Reasoning in FODAL

- Full FODAL (thus SBVR) is undecidable, so we concentrate on the fragment which is relevant in practice.
- The **description logic** fragment is a perfect candidate, since it also provides mechanisms facilitating translation into OWL2 ontologies.
- Our approach to reasoning is based on reducing the satisfiability in our fragment of FODAL to that of $\mathcal{ALCQI}$ description logic.

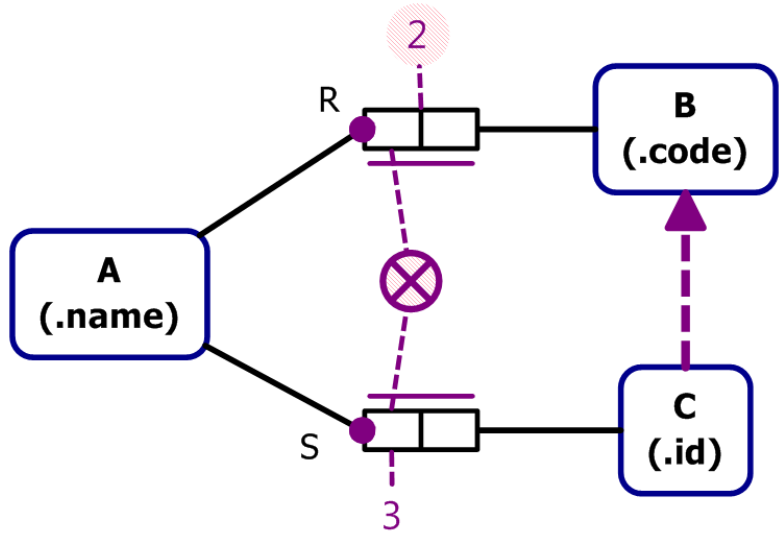
Automated Reasoning Support Tool



The functionality of the developed tool includes:

- Checking the consistency of a given set of business rules.
- Translating a set of necessity rules of a given ORM2 schema into OWL2 ontology.

Checking the consistency of a given set of rules



Halpin and Morgan, 2008, p.295

```
ENTITYTYPES: {A, B, C}
RELATIONS: {R, S}
TYPE(R.a, A)
TYPE(R.b, B)
TYPE(S.a, A)
TYPE(S.c, C)
LOC-ROLES-INDEX: {(R.a, 1),(R.b, 2), (S.a, 1), (S.c, 2)}
FREQ({S.a}, (1,3))
O-SETisa({C}, B)
MAND({R.a}, A)
MAND({S.a}, A)
\OB{ R-SETexc({R.a}, {S.a}, {(R.a, S.a)}) }
```

Checking the consistency of a given set of rules

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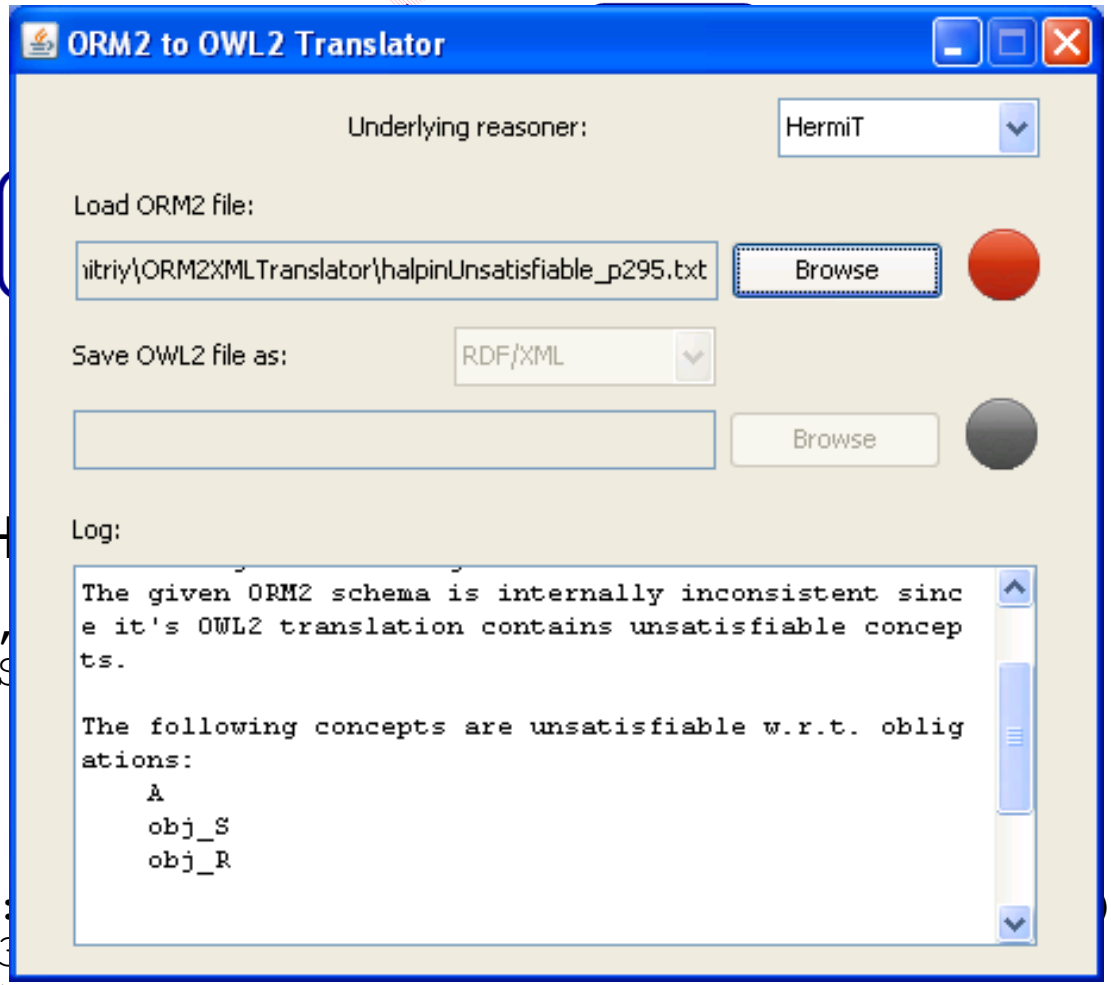


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Conclusion

- The FODAL logic provides underlying formalism for the SBVR standard.
- Defined formalization enables automated reasoning support for a relevant fragment of SBVR.
- Translation to OWL2 ontologies facilitates interoperation between existing modeling approaches.

Future work

- Investigate decidable extensions of the $\mathcal{ALCQI}$-expressible fragment of SBVR.
- Elaborate further reasoning tasks for business rules (e.g. entailment).
- Inquire into approach of translating a full ORM2 schema with its alethic and deontic rules to SWRL or some other extension of OWL2.