



# Assessing Ontologies via Simulation

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<http://nemo.inf.ufes.br>

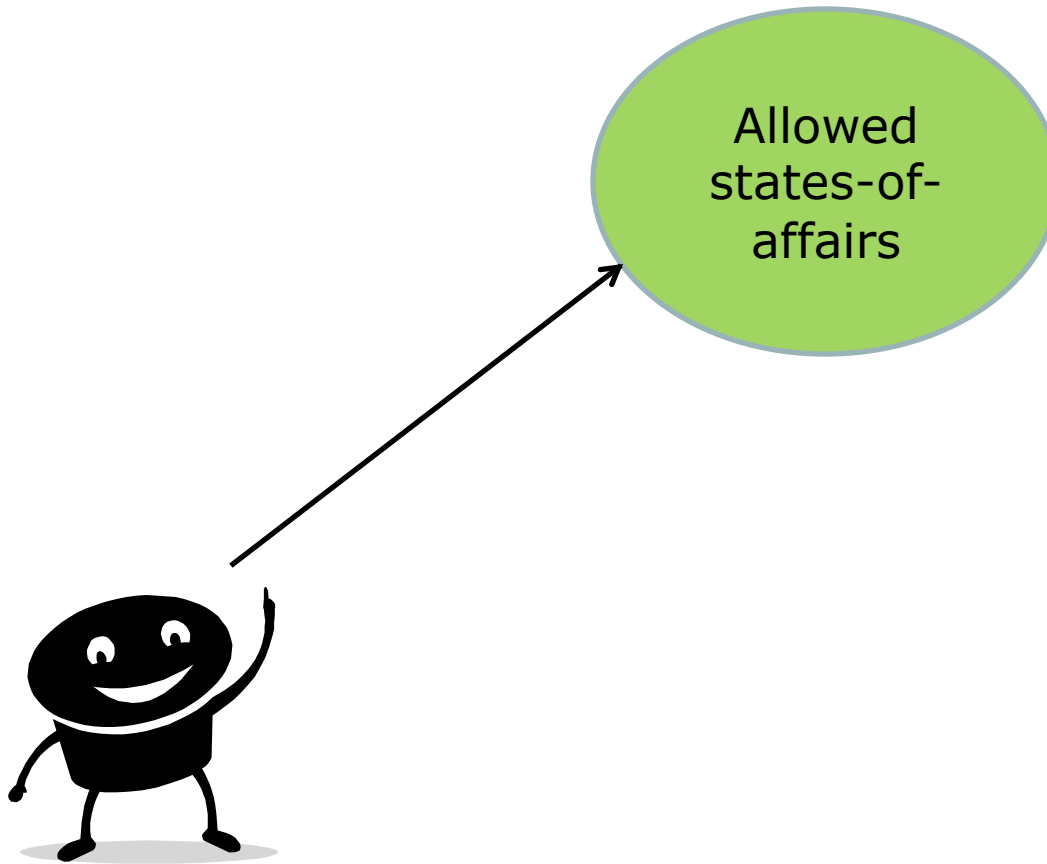
Computer Science Department  
Federal University of Espírito Santo

# Motivation

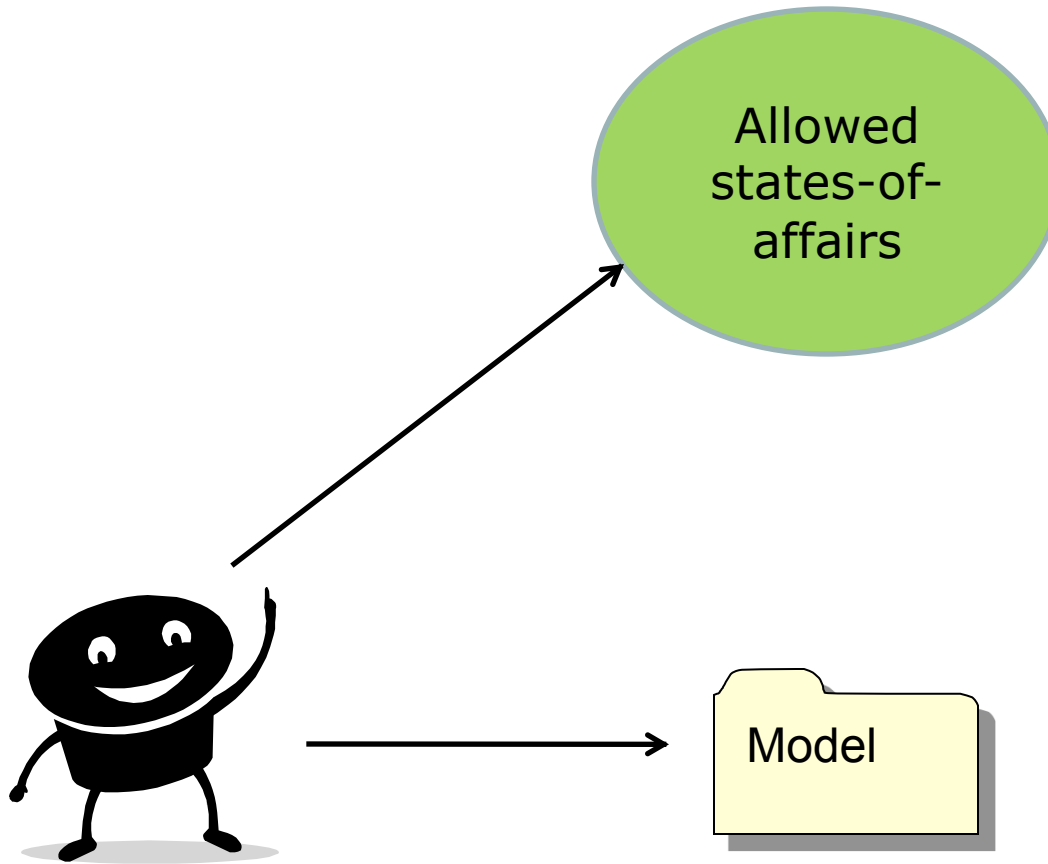
- We see conceptual models as a means to represent the categories that modelers (or subject matter experts) perceive in some portion of the physical and/or social world
  - **represent the modeller's intended conceptualization**
- The model should ideally:
  - **describe all states of affairs that are deemed admissible and**
  - **rule out those deemed inadmissible**
  - (according to the conceptualization)
- Assessing the quality of conceptual models is key to ensure that conceptual models can be used effectively as a basis for understanding, agreement and construction of information systems.

# Conceptualization

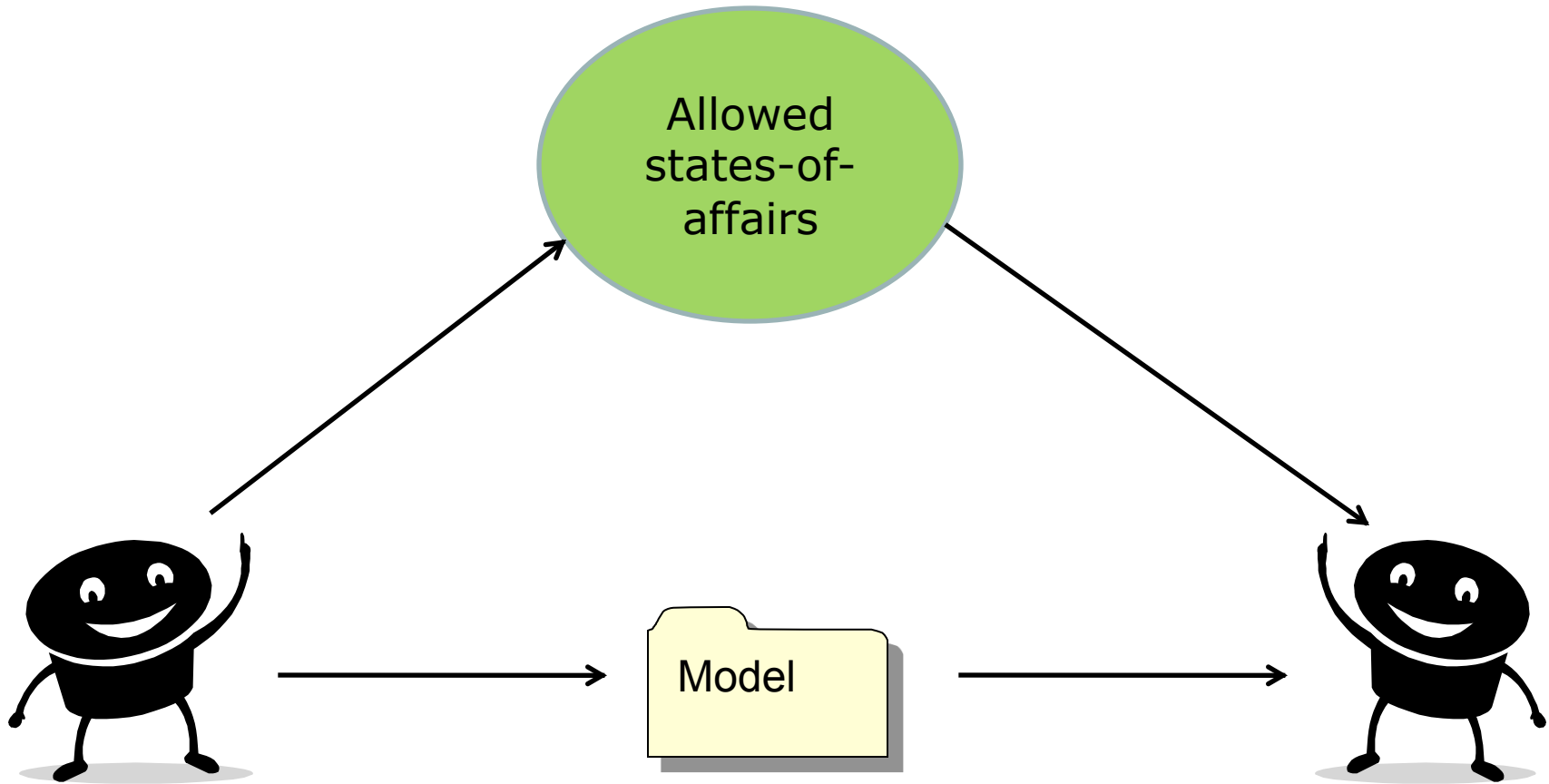
(entities that are allowed to exist,  
their properties and relations, ...)



# Writing a model



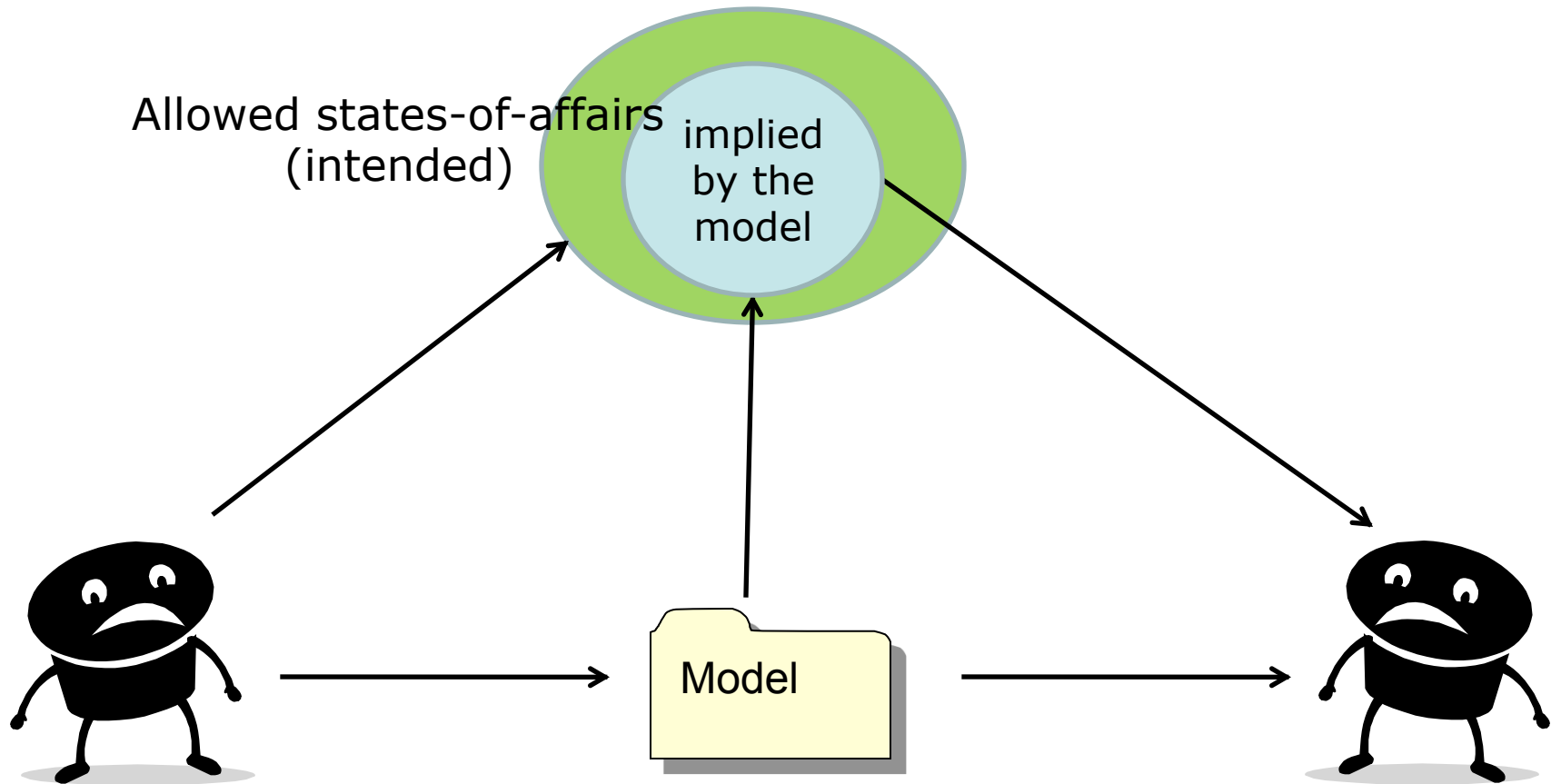
# Interpreting a model



# Intended x Modeled States-of-Affairs

Model is overconstrained

A mistake of the modeller?

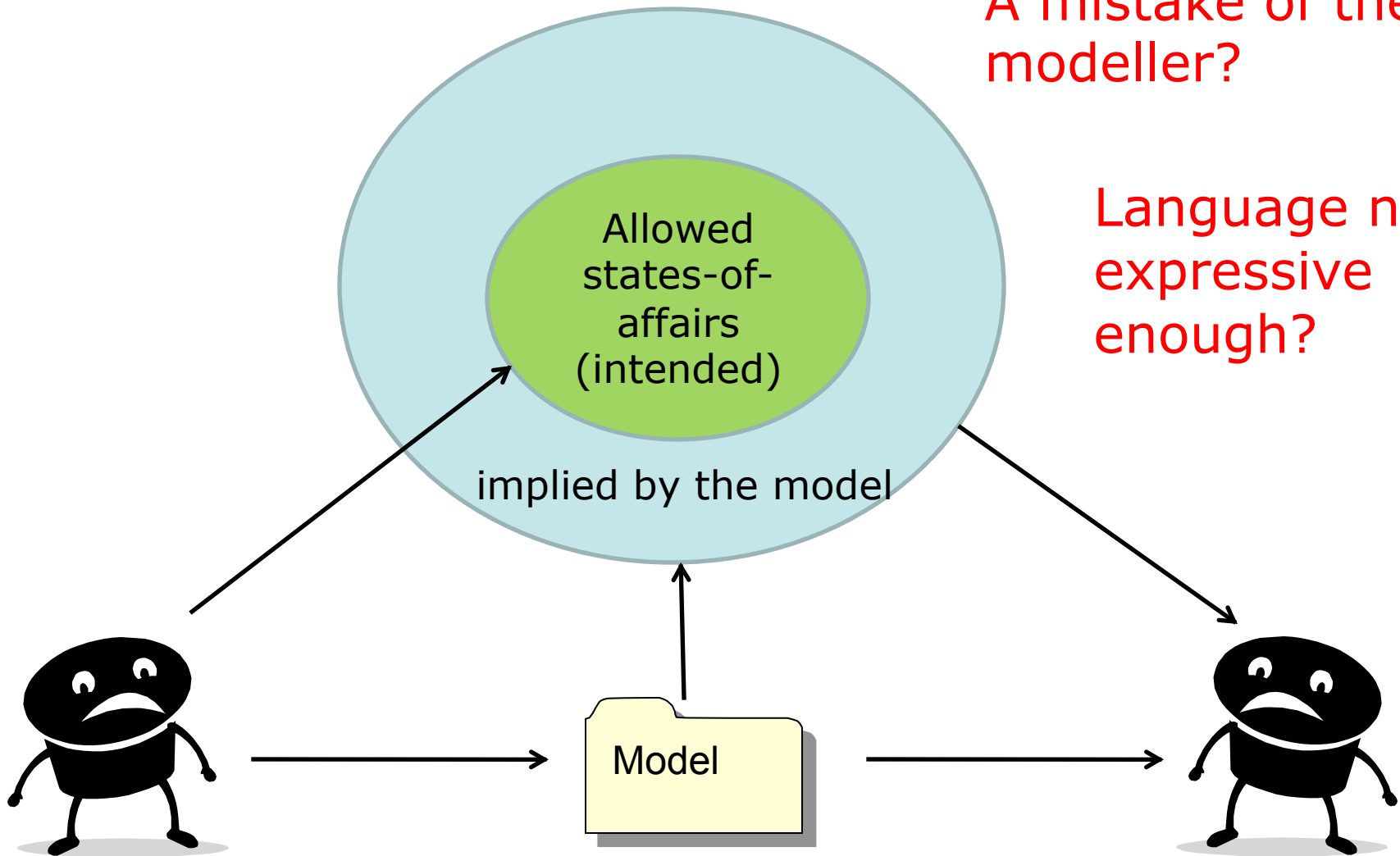


# Intended x Modeled States-of-Affairs

Model is underconstrained

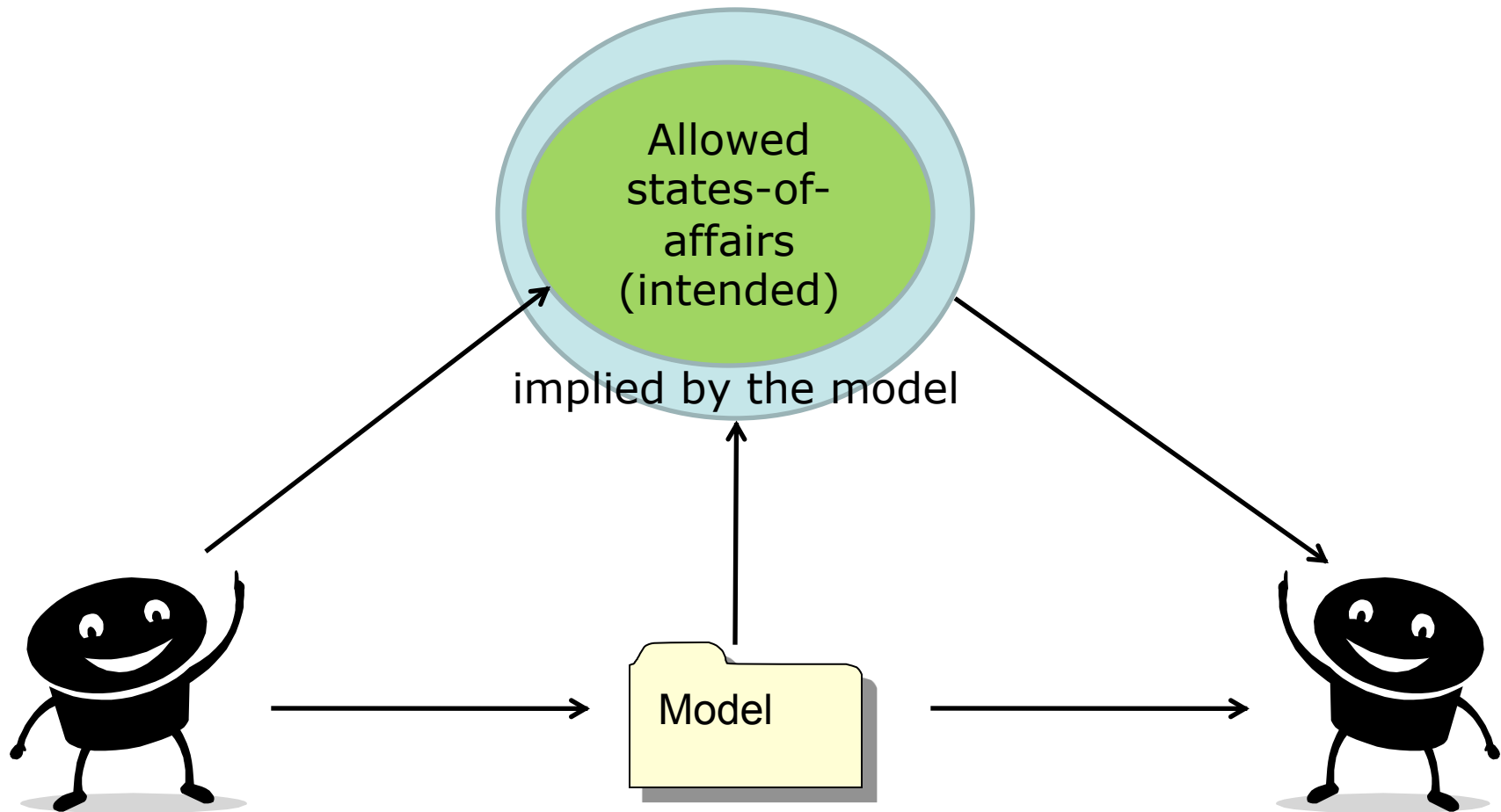
A mistake of the modeller?

Language not expressive enough?



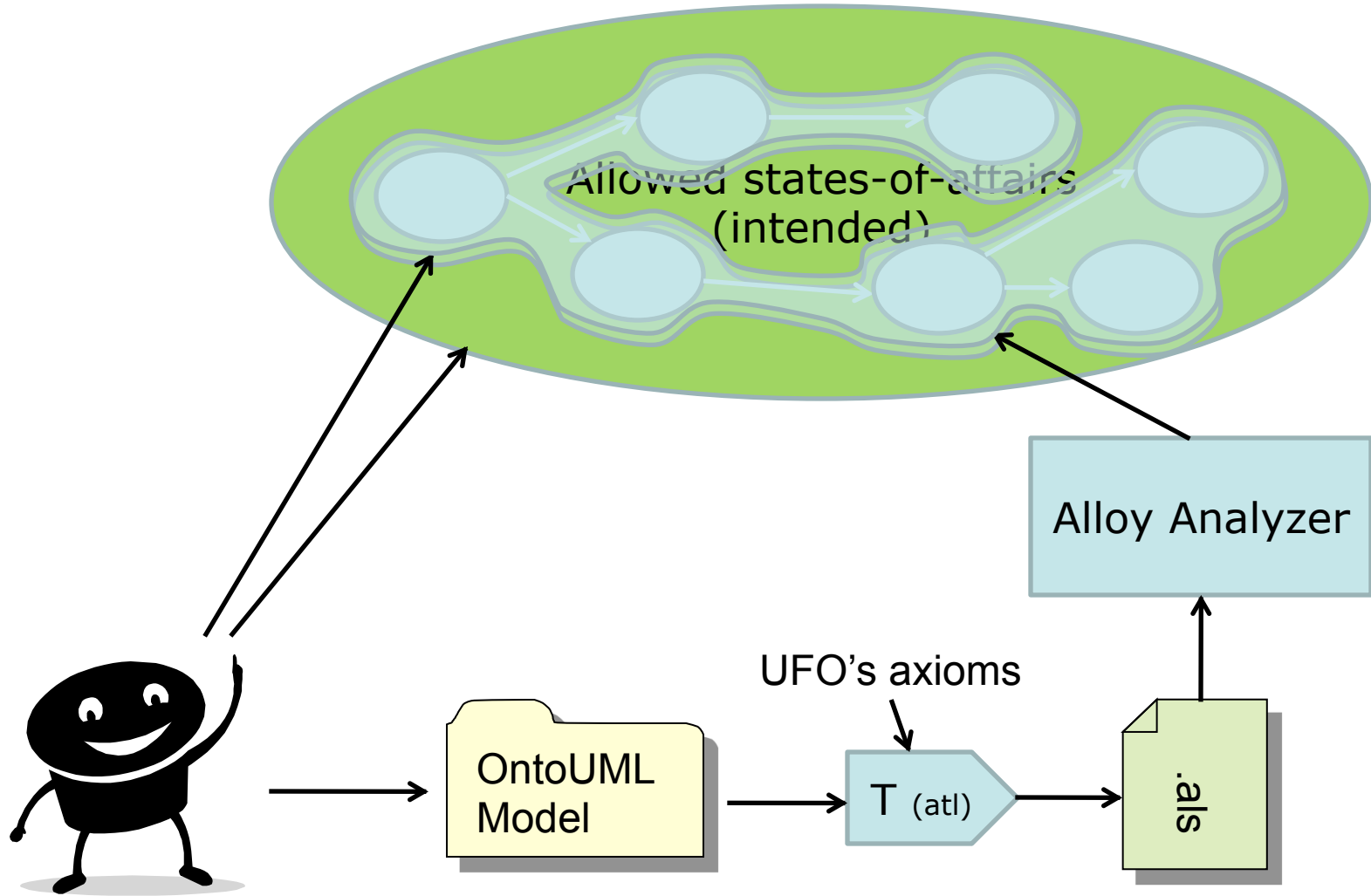
# Intended x Modeled States-of-Affairs

High precision  
And coverage



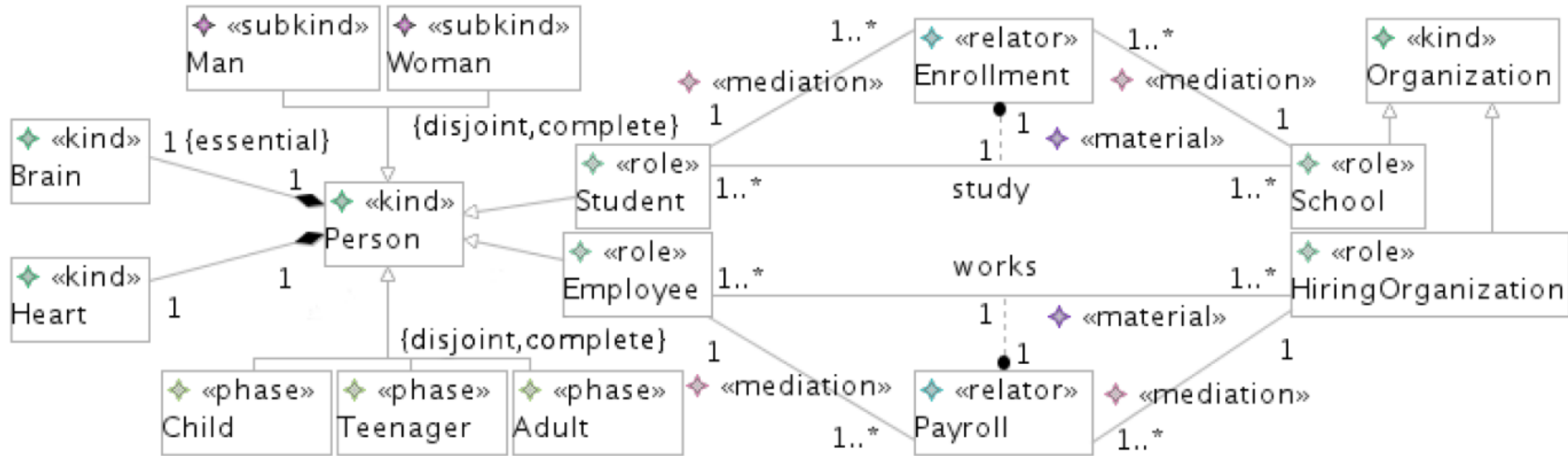


# Our Approach: Transform OntoUML Model into Logic-Based Alloy for Simulation

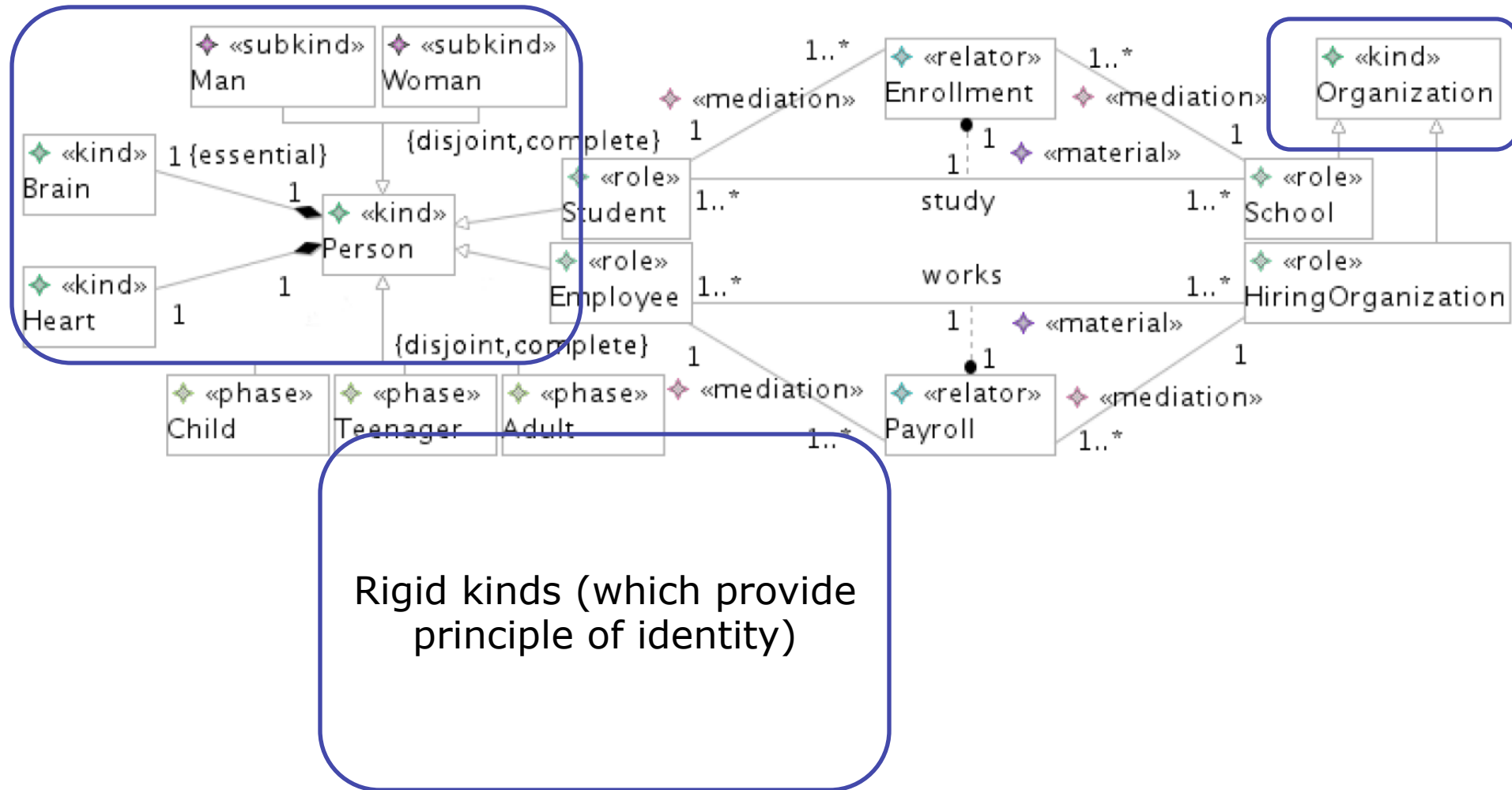


- UML profile that incorporates the theory in the UFO foundational ontology
  - **finer-grained distinctions between different types of classes and different types of part-whole relations**
  - **rich syntactic constraints**
  - Incorporates advances from DOLCE & OntoClean, GFO & GOL
- Modal meta-properties for object classifiers
  - Distinguishing rigid, semi-rigid and anti-rigid classifiers
    - (and therefore distinguish properties that apply necessarily to objects from those that apply contingently)
- Meta-properties for part-whole relations
  - mandatory, essential, inseparable and immutable parts, and immutable wholes

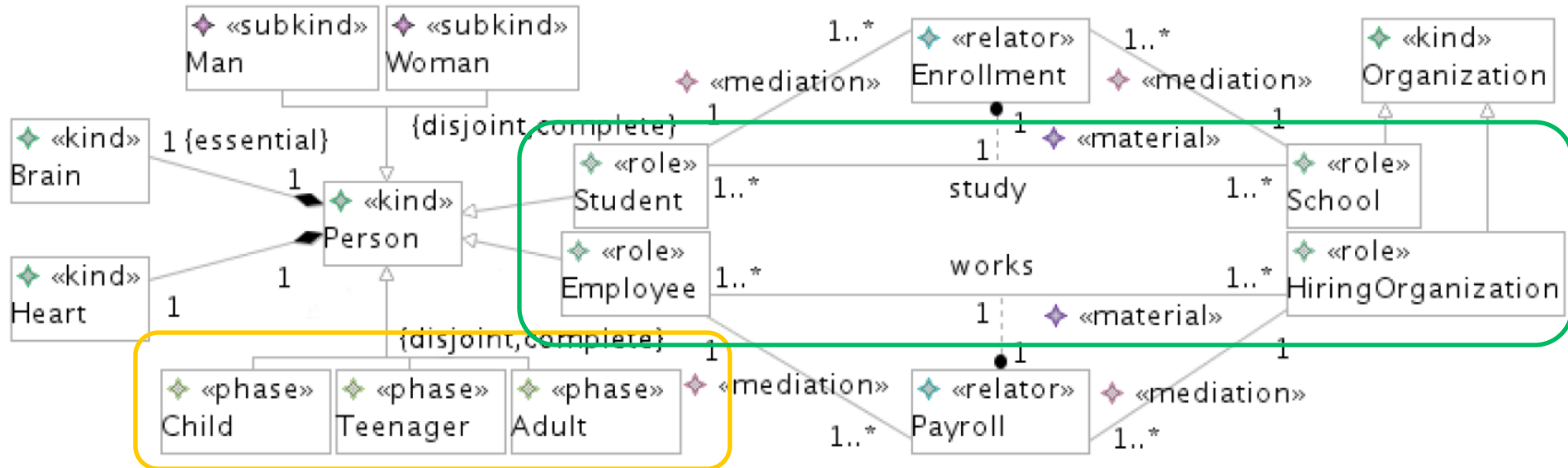
# An Example



# An Example: Rigid Universals



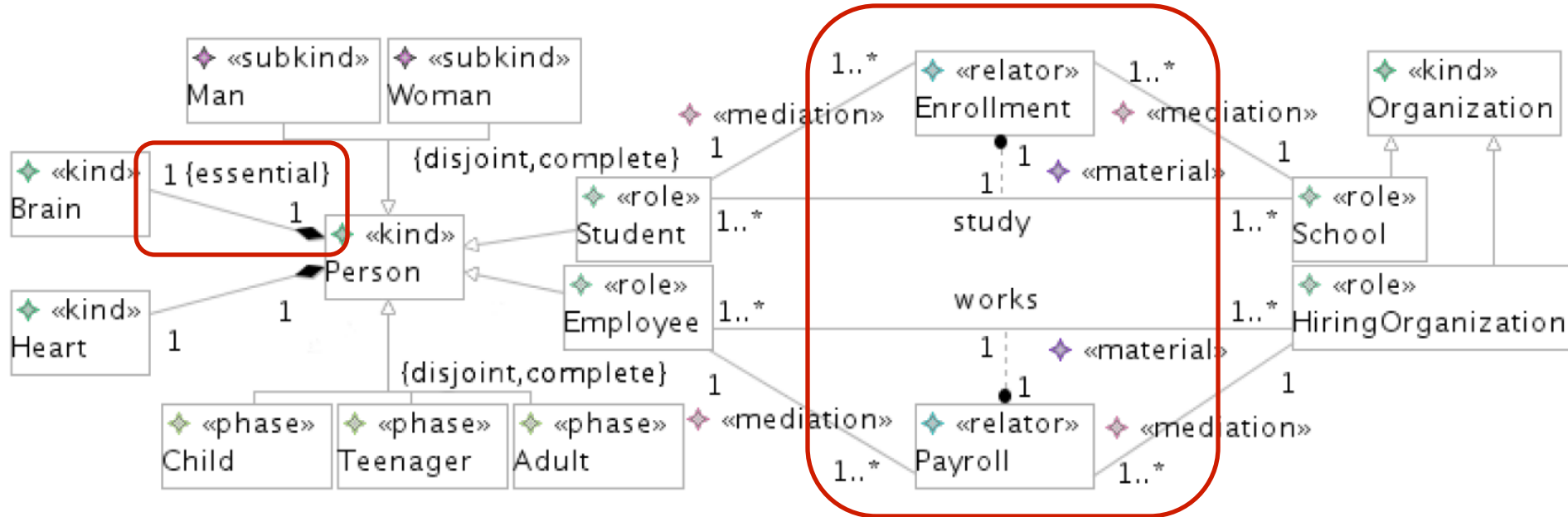
# An Example: Anti-Rigid Universals



Anti-rigid, defined by intrinsic properties

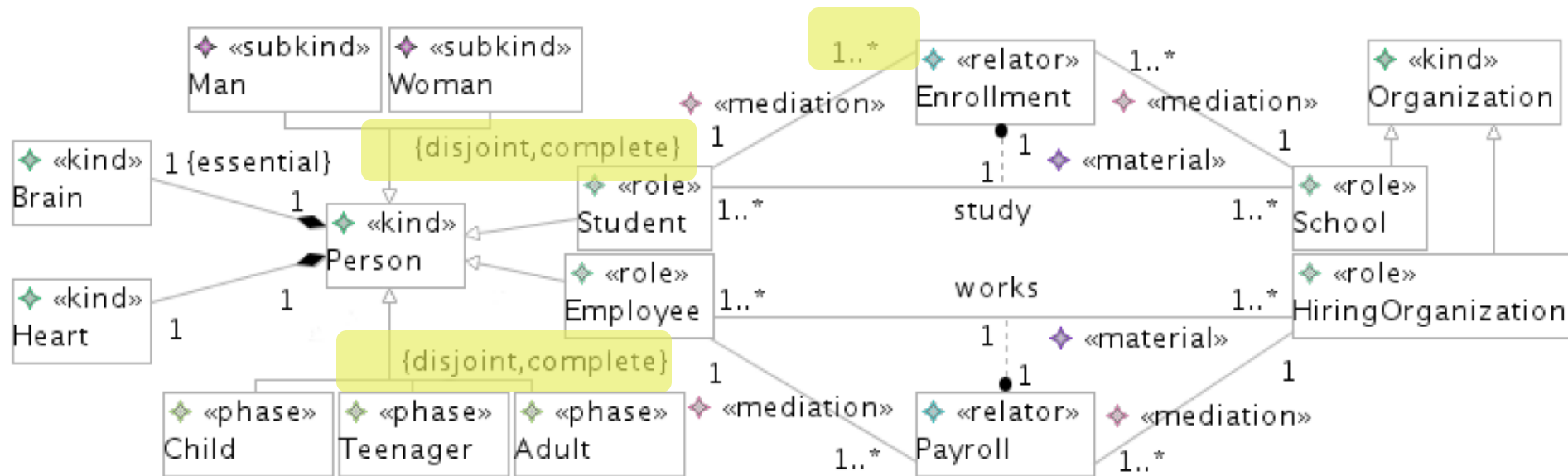
Anti-rigid, relationally dependent

# An Example: Existential Dependence

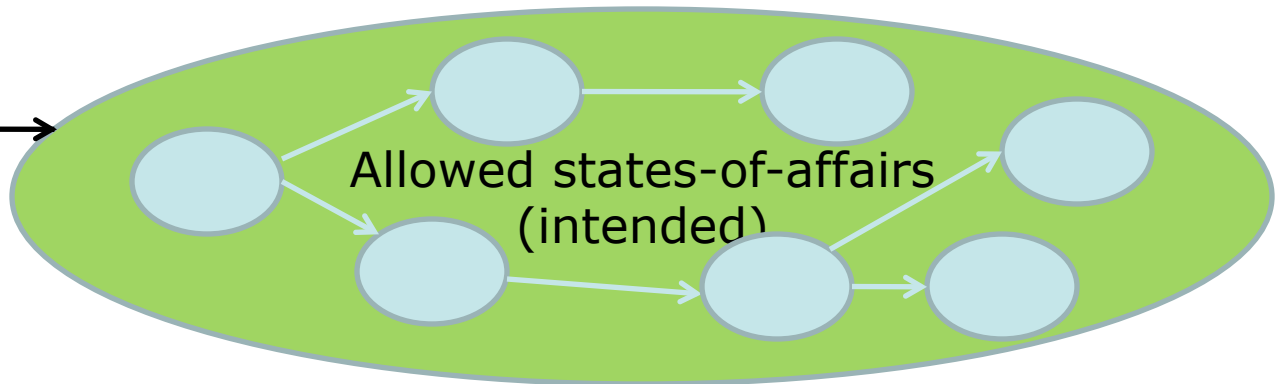
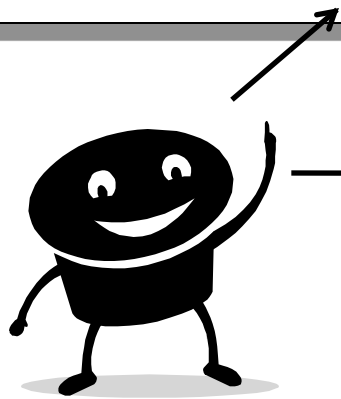
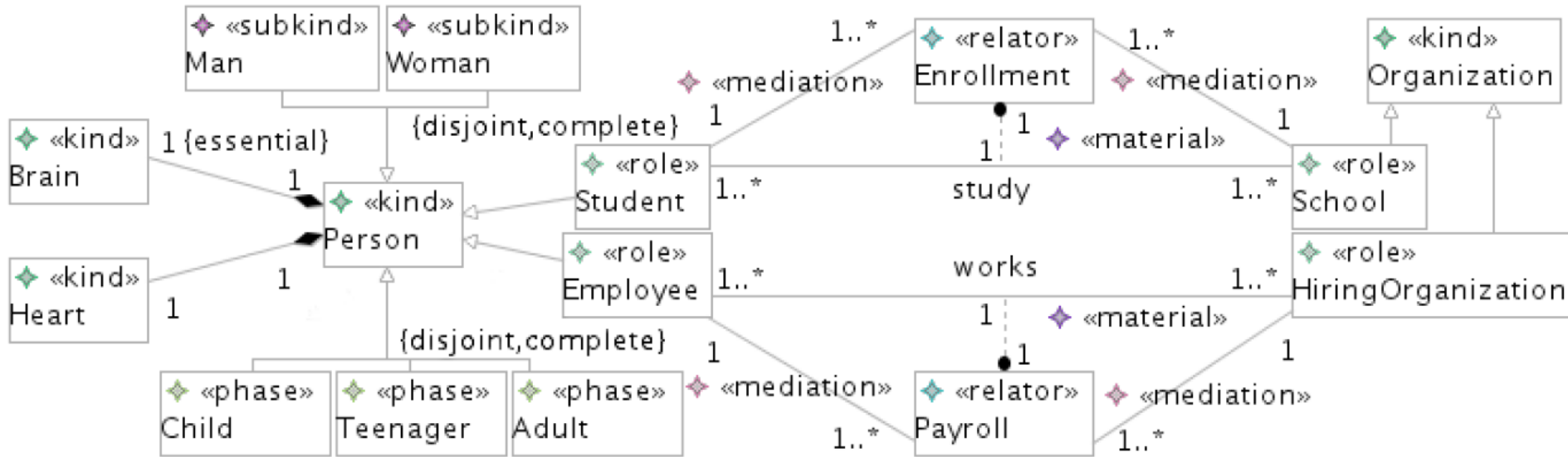


Existential dependence

# An Example: Additional constraints...



# An Example





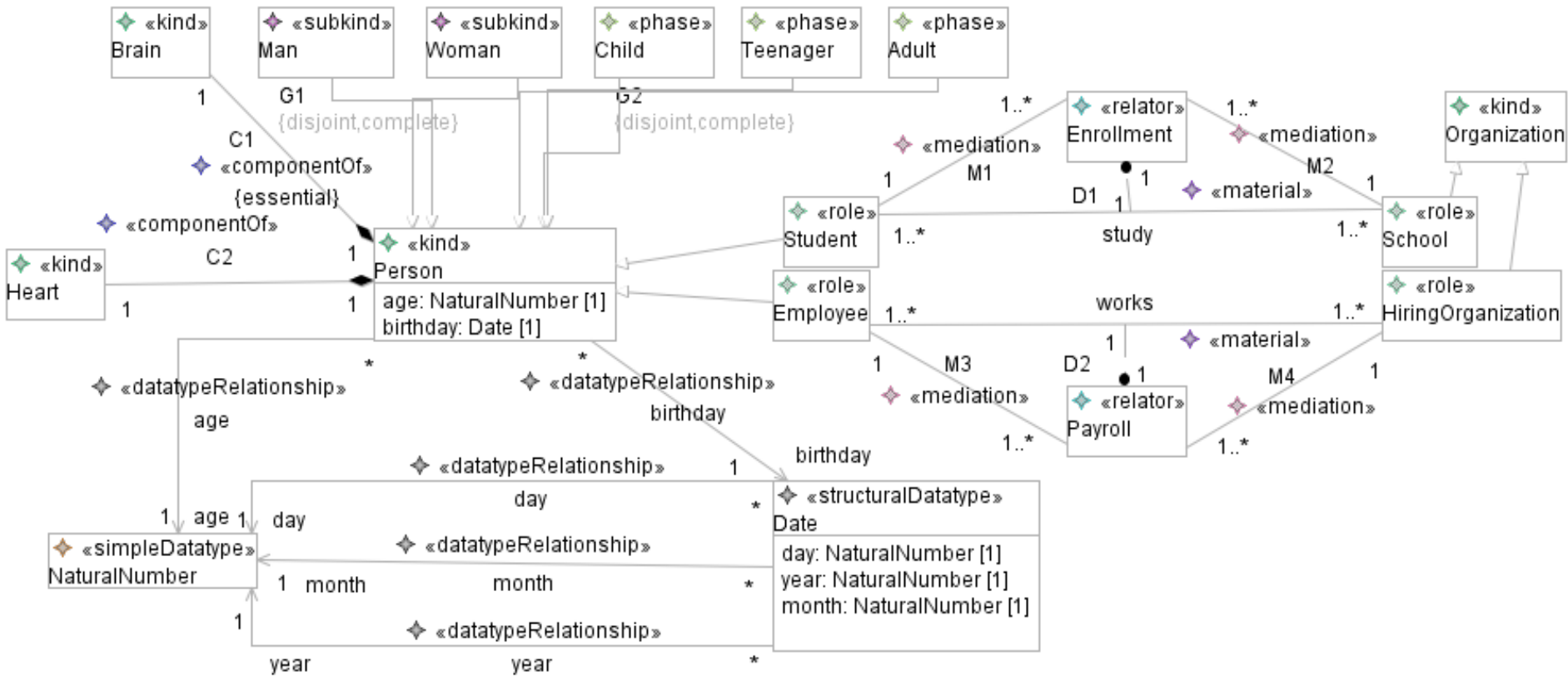
# Alloy

- A model in Alloy consists of logical constraints which are captured in *signatures* and *fact declarations*.
- When a model is instantiated by the Alloy Analyzer, *atoms* are generated from signatures respecting the logical constraints in the model.
- Signatures can include field declarations, introducing relations between signatures.
- No notion of state change, dynamics or modality
- Analyzer can generate instances and produce counter-examples for predicates

# Transformation

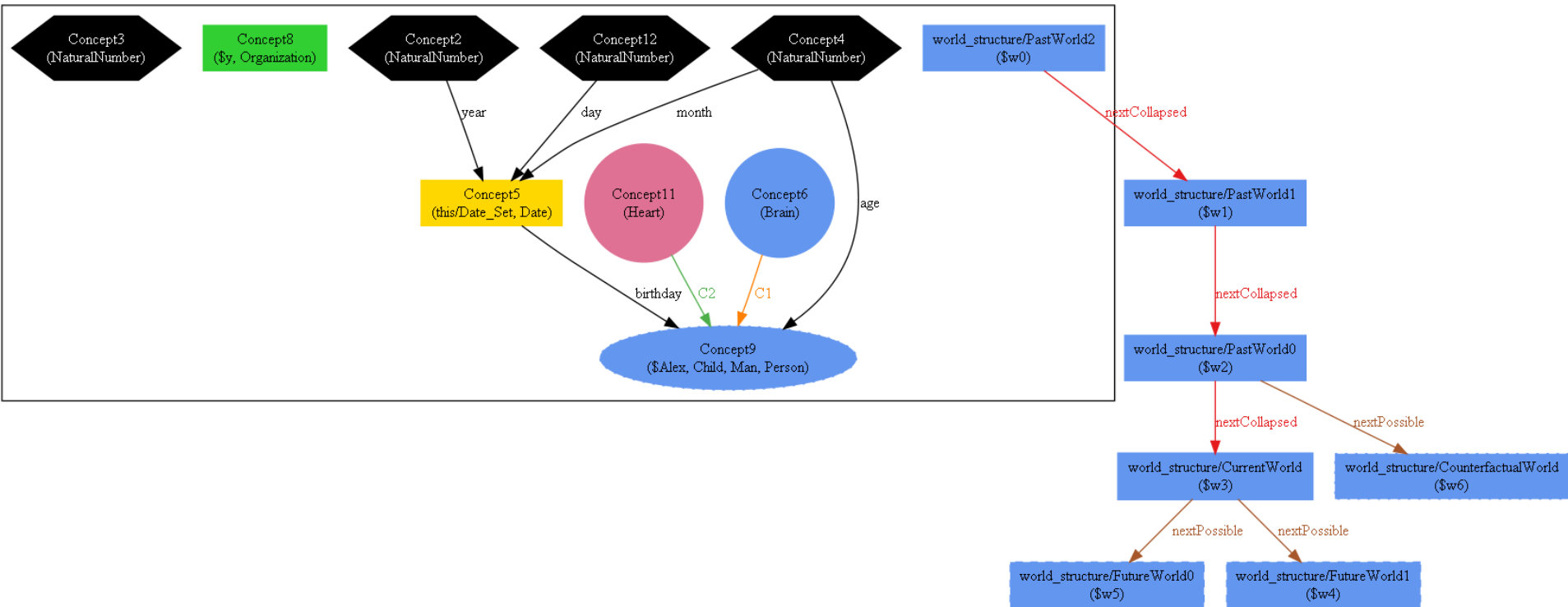
- Reify worlds and accessibility relation in Alloy
- Branching-time Kripke structure
  - Past worlds, current world, future worlds & counterfactual worlds
- The characteristics of the OntoUML classes (e.g., rigidity, anti-rigidity) and the ones of the relationships (e.g., cardinality constraints, shareability, existential dependency and disjointness) are mapped into constraints in Alloy

# Example



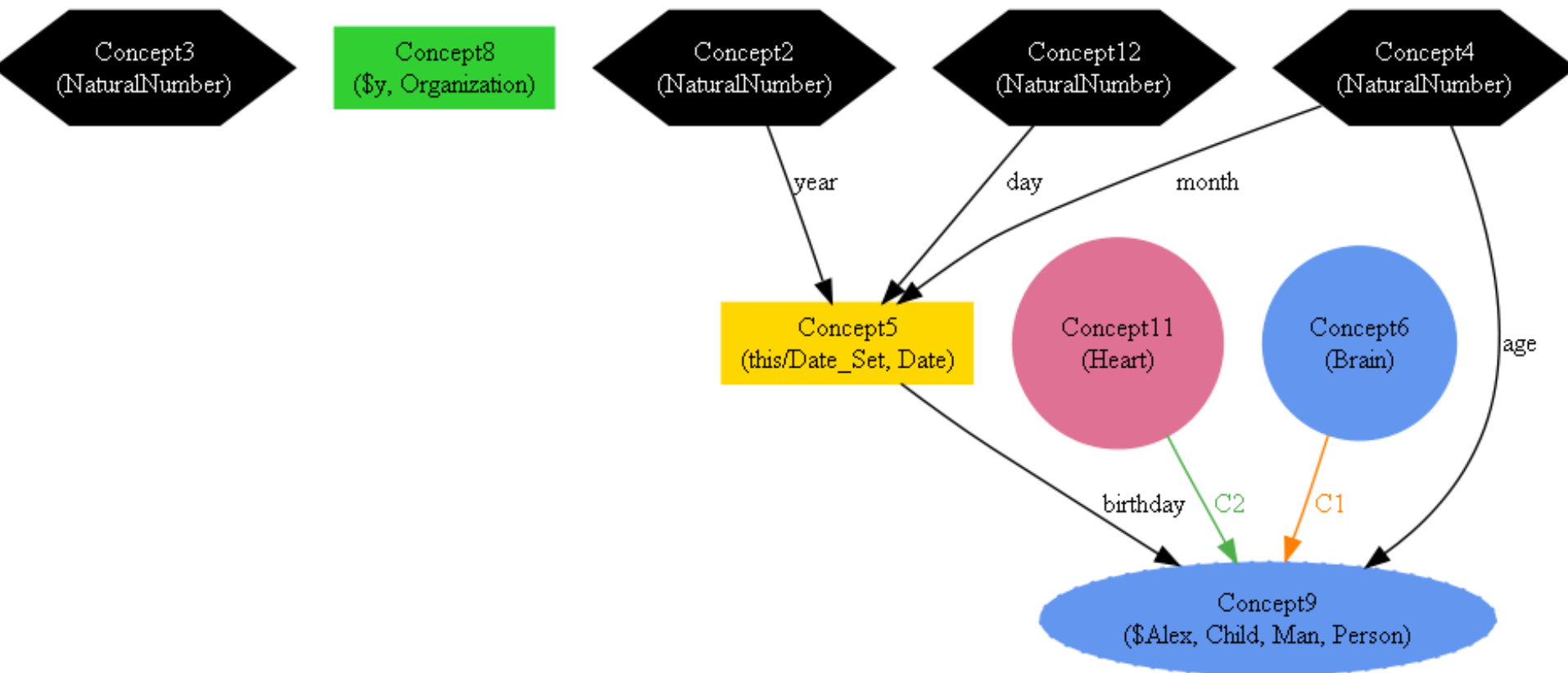
# Example: PastWorld2

## Alex is a Child



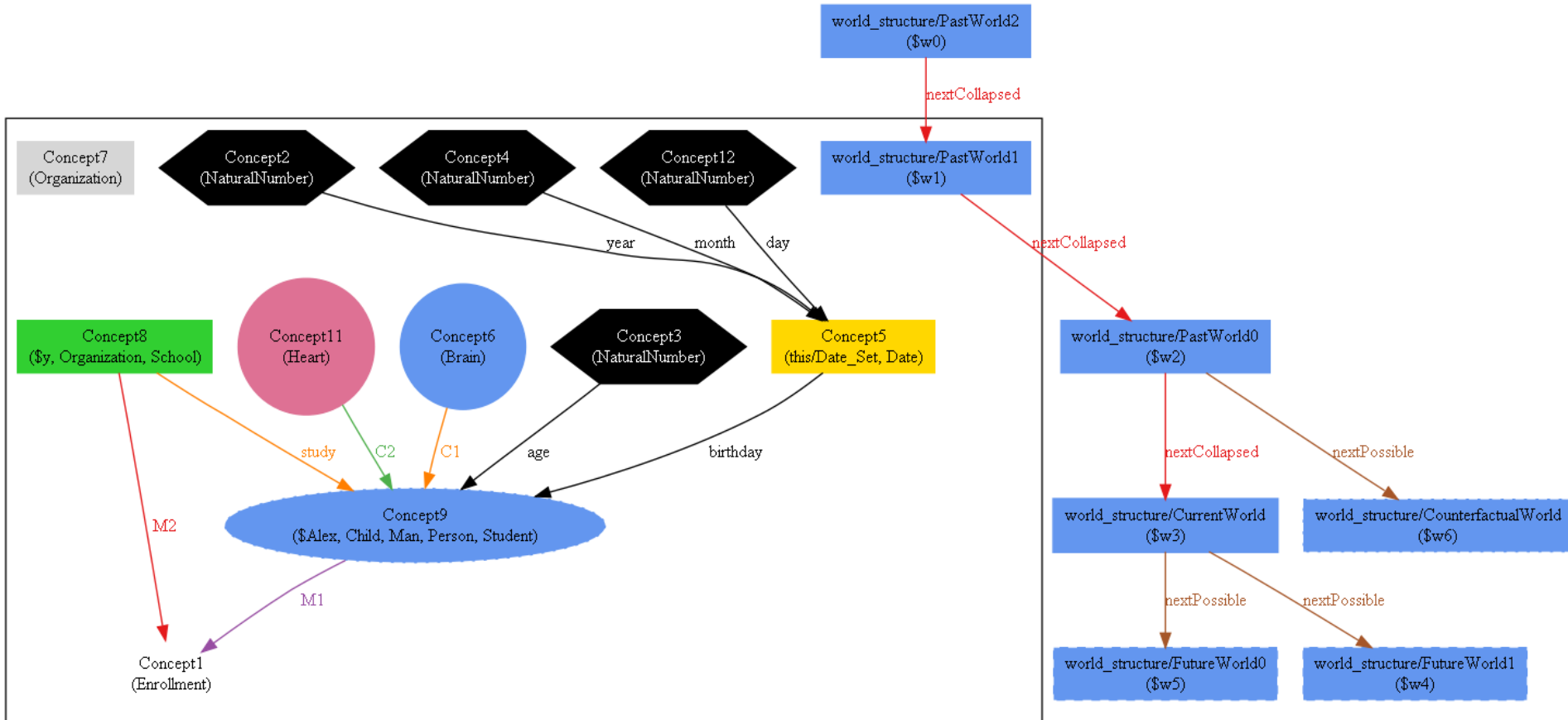
# Example: PastWorld2

## Alex is a Child



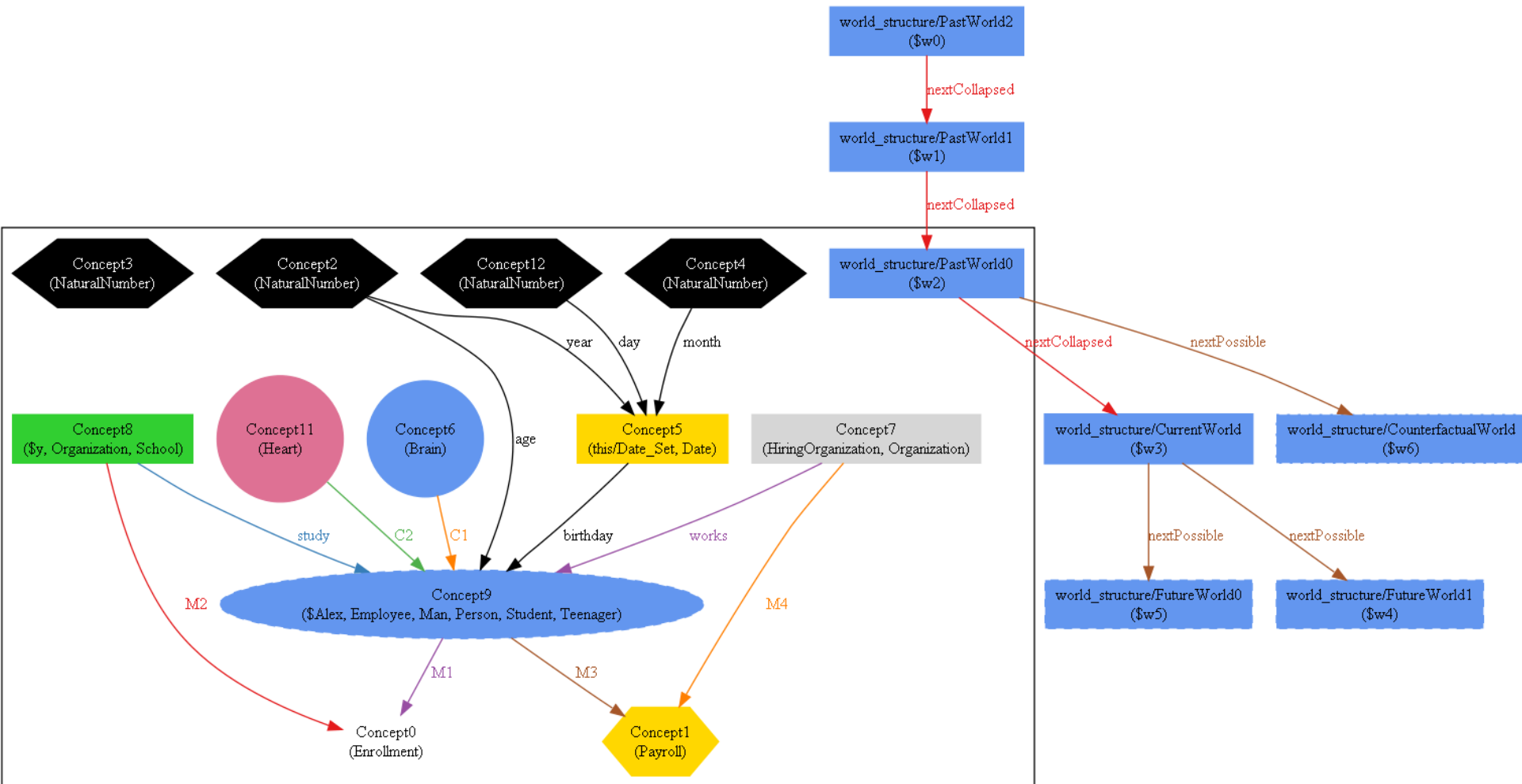
# Example: PastWorld1

Alex changes age, becomes a Student,  
Concept8 is School, Organization appears

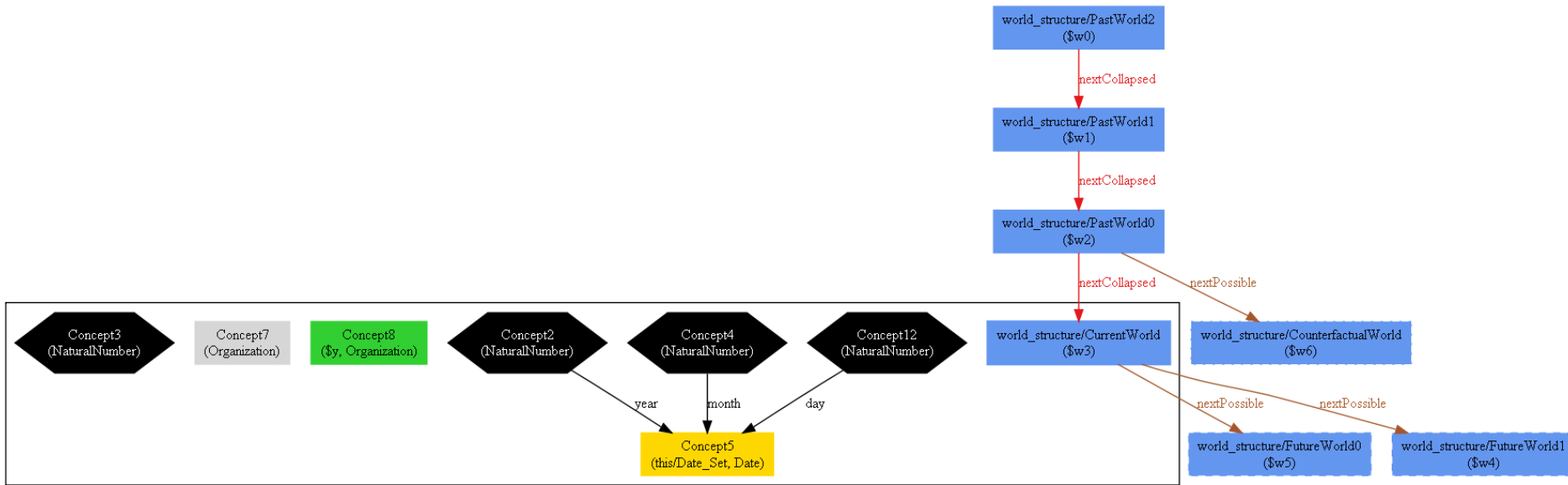


# Example: PastWorld0

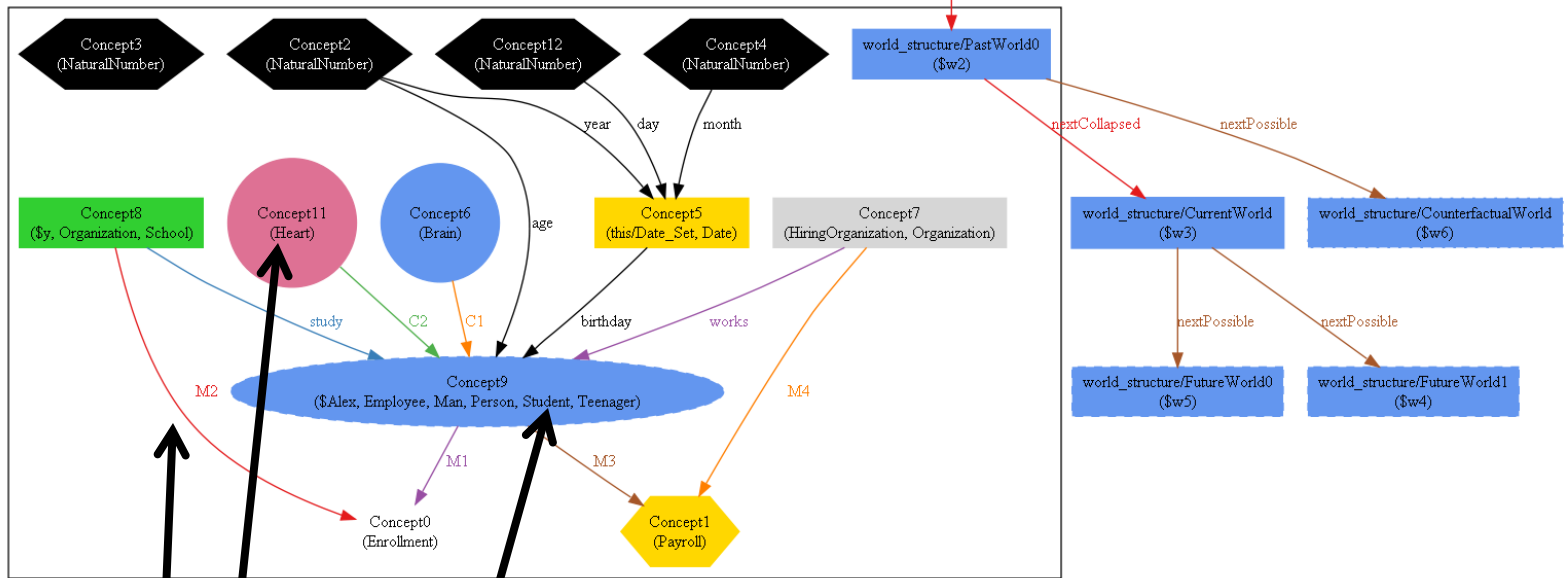
Alex is Employee (and still a Student),  
becomes Teenager



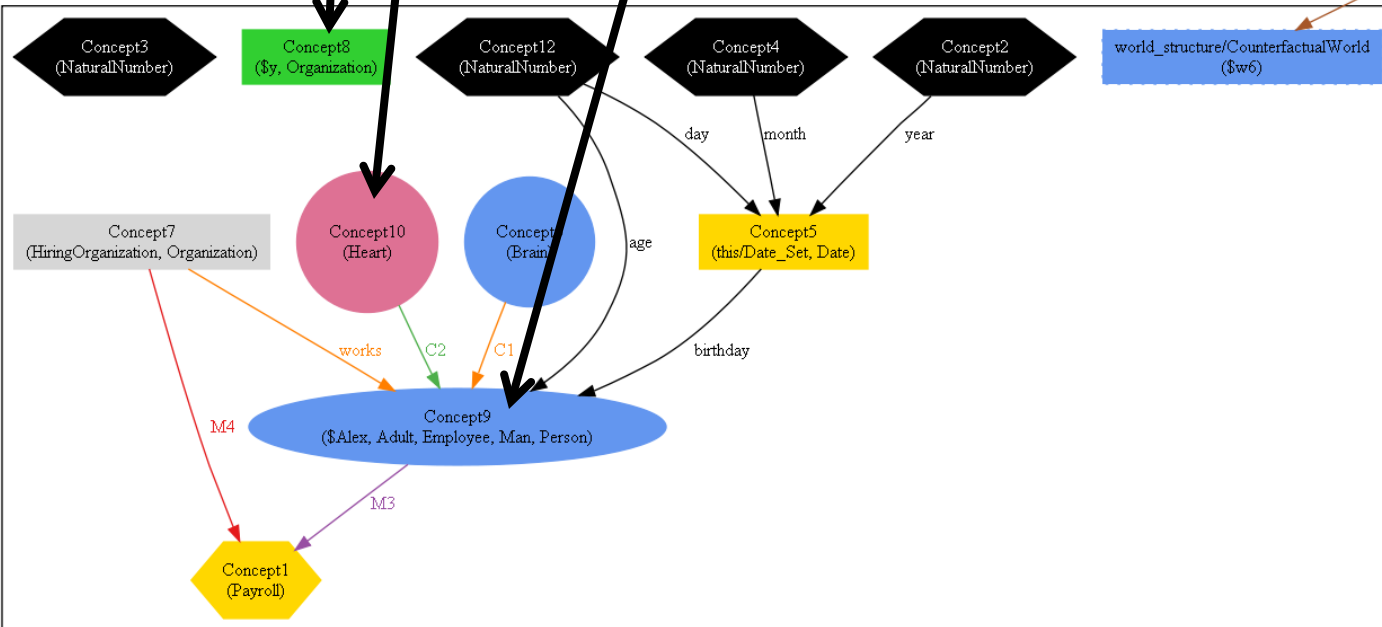
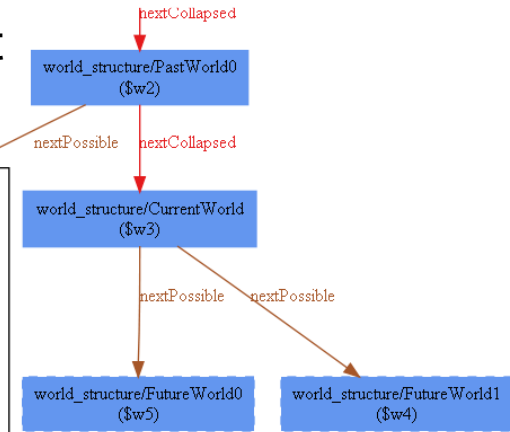
# Example CurrentWorld: Alex no longer exists







Alex undergoes heart transplant  
And is no longer a student



# OCL constraints

- To guide the verification one may add invariants which can be checked for consistency
  - If examples can be produced, invariants are consistent
  - (it is possible to satisfy the invariant)
- Or add invariants which we believe are implied by the model
  - If counterexamples are found than the intuition was wrong
  - (if counterexample is not found, then invariant is guaranteed to hold for all instances up to a certain size)
- We have implemented an OCL to Alloy transformation which allows us to express these invariants without knowledge of Alloy

# Limitations

- Support models which are finitely instantiable
- Scope and scalability
  - Appeal to the “small scope hypothesis”
  - Exhaustive model checking becomes intractable with large number of instances

# Conclusions

- A mature approach to conceptual modelling requires tools for modellers to gain confidence on the quality of the models they produce
- Our approach shows the possible dynamics of object creation, classification, association and destruction as defined in the conceptual model
- Snapshots confront the modeller with what he/she wrote
- Modalities are exercised in the generated world structure
- Verification of invariants with generation of counterexamples
- Tools available for download at <http://nemo.inf.ufes.br>

# Future work

- Explore visualization techniques and perform empirical validation
- Support for temporal constraints
- Analysis and verification
  - What kinds of assertions are interesting for analysis?
  - A catalogue of patterns which reveal common mistakes (“warnings”)

# Acknowledgements



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- John Guerson
- Tiago Prince Sales

# References

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- BRAGA, B.F.B. ; ALMEIDA, J. P. A. ; GUIZZARDI, G. ; BENEVIDES, A. B. . Transforming OntoUML into Alloy: towards conceptual model validation using a lightweight formal method. *Innovations in Systems and Software Engineering*, Springer, v. 6, p. 1-13, 2010.

# About NEMO



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