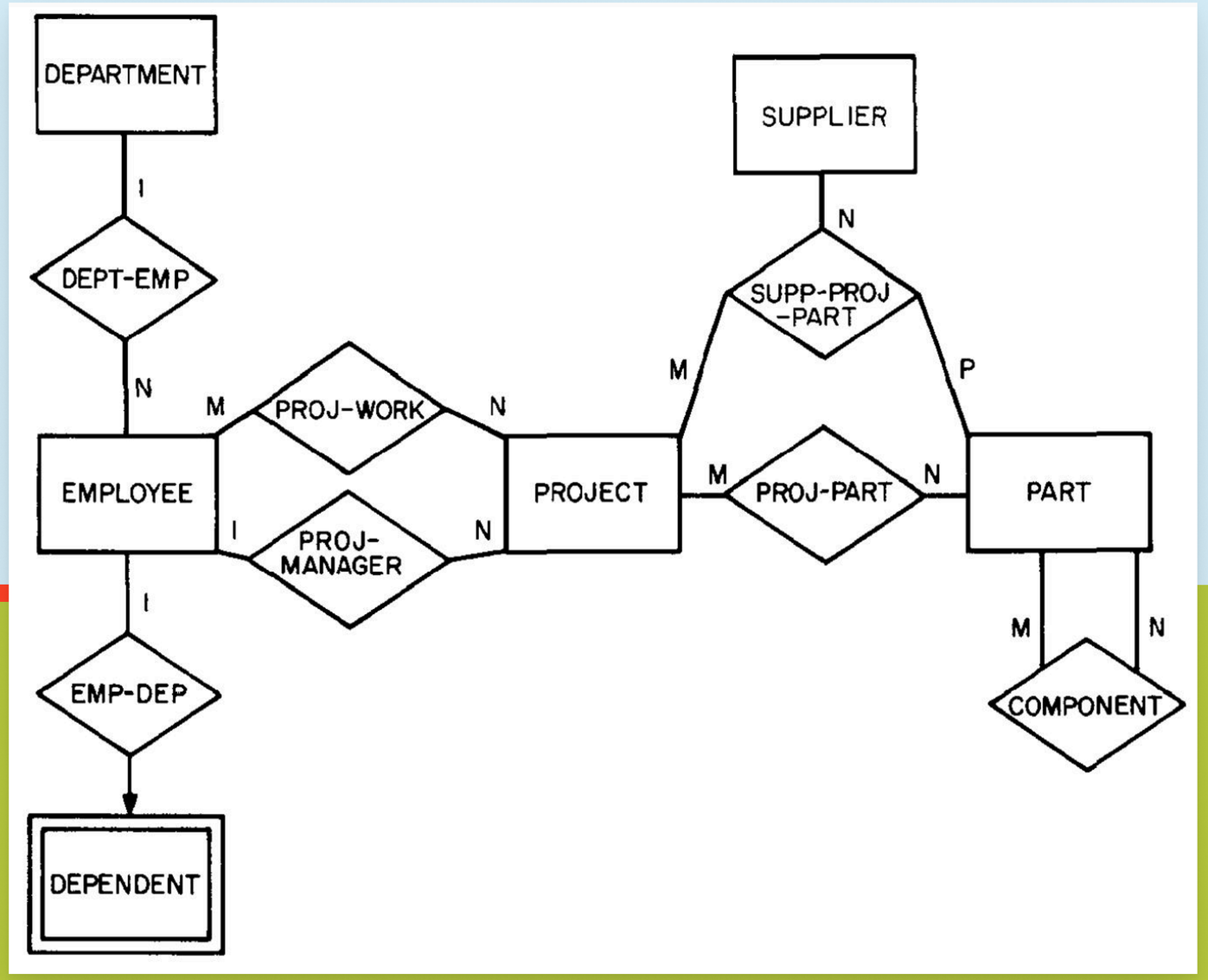
Conceptual modeling, explanation, abstraction, and all that

Elena Romanenko



Prof Diego Calvanese
Prof Giancarlo Guizzardi
Prof Oliver Kutz

Based on collaborative work and joint publications

AGENDA

01
State-of-the-art in conceptual modeling

02
If you understand it, you can use it!

03
Abstraction as part of the explanation process

04
ExpO prototype

05
Future directions

DISCLAIMER

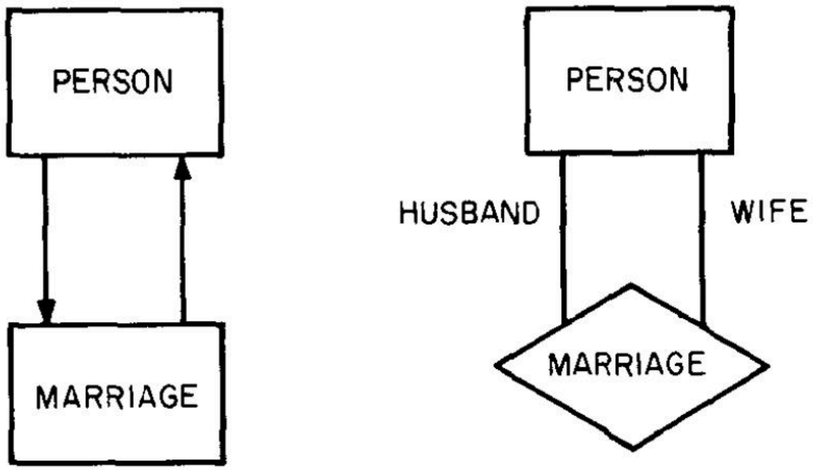
Ontology, Foundational Ontology
Conceptual model, Domain Ontology
Ontology-Driven Conceptual Model

“an explicit specification of a conceptualization” (Gruber)

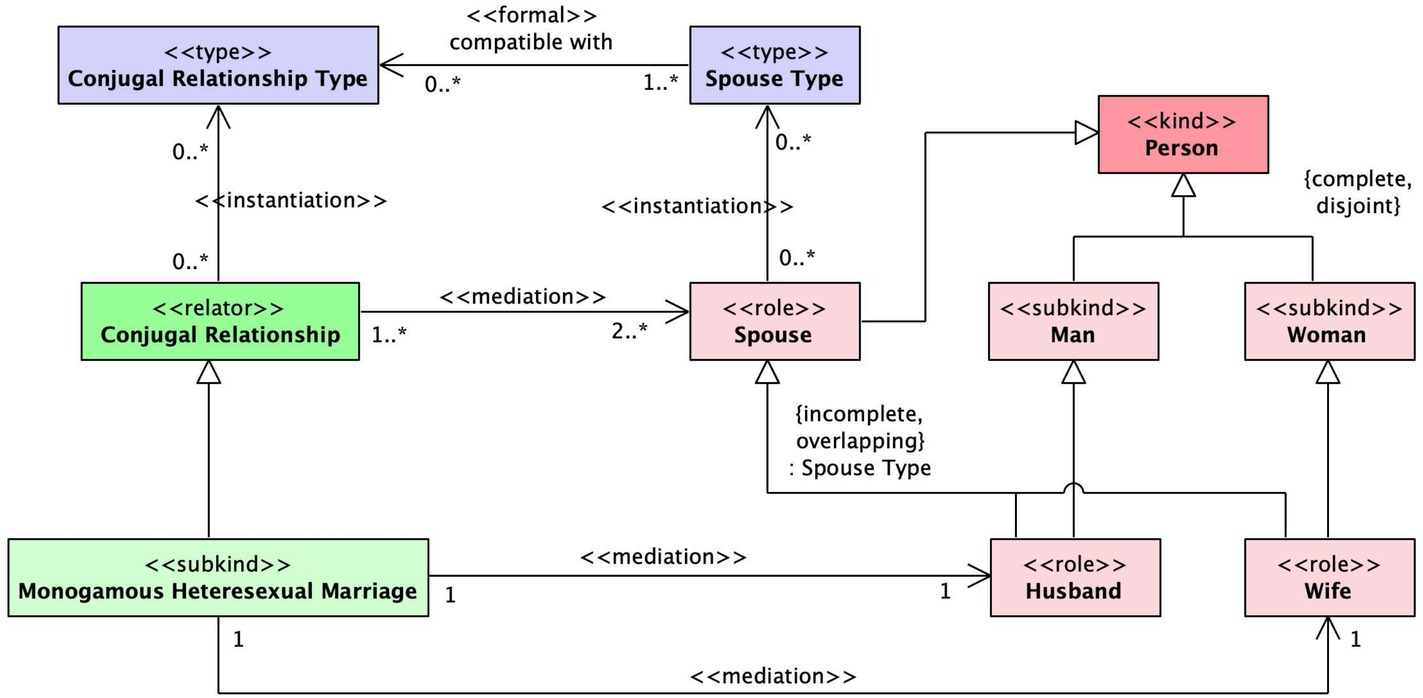
“the configuration of conceptual elements and the navigation between them” (Parush)

“any model that is formed after a conceptualization or generalization process” (Wiki)

“a high-level, abstract representation that helps people understand and communicate the essential aspects of a system, idea, or domain” (ChatGPT)



ER MODEL (1976)



ONTOUML MODEL (2022)

SURVEY

Conceptual Modeling: Topics, Themes, and Technology Trends

Authors: Veda C. Storey, Roman Lukyanenko, Arturo Castellanos | Authors Info & Claims

ACM Computing Surveys, Volume 55, Issue 14s • Article No.: 317, Pages 1 - 38 • https://doi.org/10.1145/3589338

Published: 17 July 2023 Publication History

Check

8 1,274

Data & Knowledge Engineering 154 (2024) 102351

Contents lists available at ScienceDirect

Data & Knowledge Engineering

journal homepage: www.elsevier.com/locate/datak

ELSEVIER

Unraveling the foundations and the evolution of conceptual modeling—Intellectual structure, current themes, and trajectories

Jacky Akoka [a], Isabelle Comyn-Wattiau [b], Nicolas Prat [b], Veda C. Storey [c,*]

[a] CEDRIC-CNAM, Paris, France
[b] ESSEC Business School, Cergy-Pontoise, France
[c] Computer Information Systems, J. Mack Robinson College of Business, Georgia State University, Atlanta, GA, United States

Systematic literature review AND bibliometric analysis

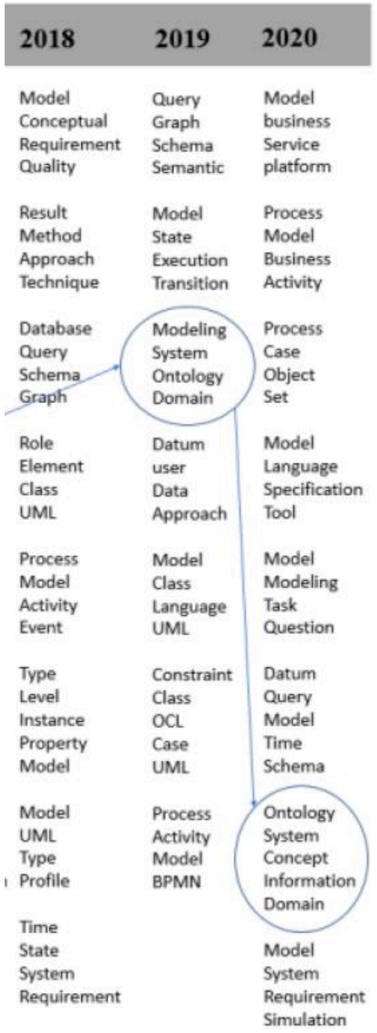
Conceptual Modeling: Topics, Themes, and Technology Trends

5,300 papers from 35 related journals and conferences
(ER, CAiSE, ICIS, AMCIS, EMISAJ, DKE, ...)

1976--2022

natural language processing (LDA)

quantitative + qualitative analysis



business process design and execution

business modeling and mining

process analysis

modeling languages

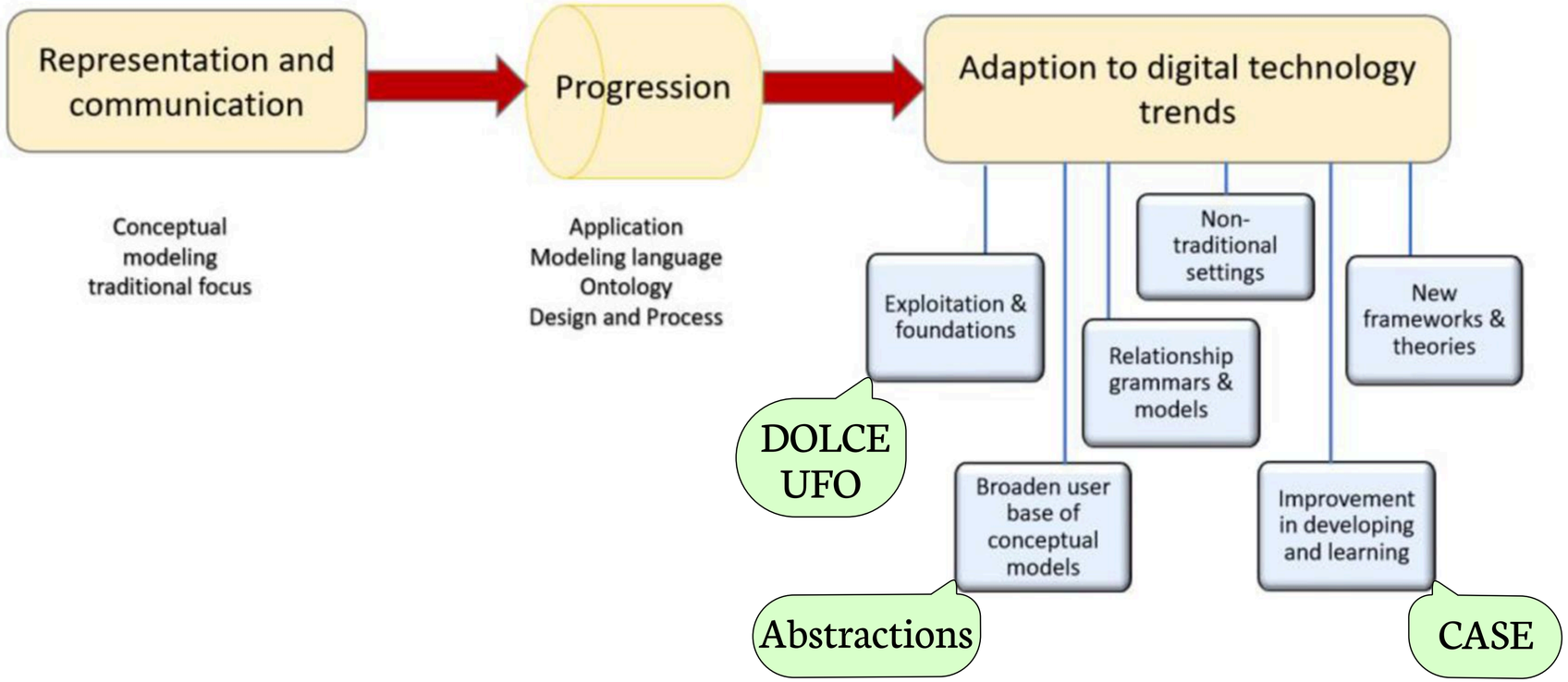
empirical evaluations

data models

ontology

software engineering

Conceptual Modeling: Topics, Themes, and Technology Trends

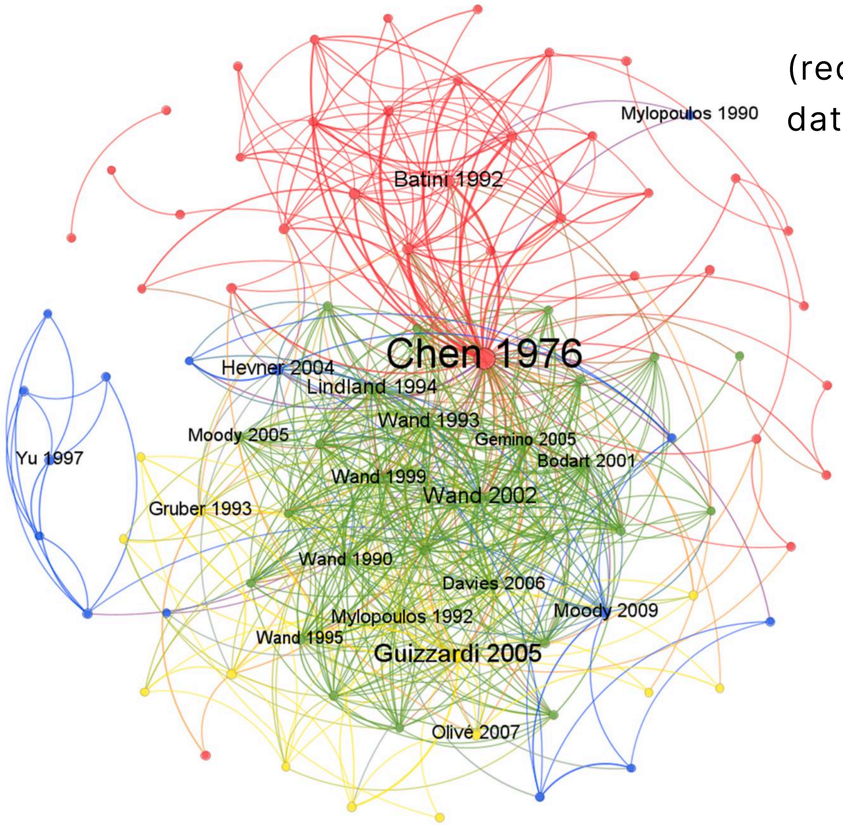


Unraveling the foundations and the evolution of conceptual modeling

4 742 documents and
110 718 (73 018 unique) cited references

1976--2023

three types of bibliometric analysis:
co-citation analysis (CCA),
bibliographic coupling analysis (BCA), and
main path analysis (MPA)



(red) Conceptual modeling and databases

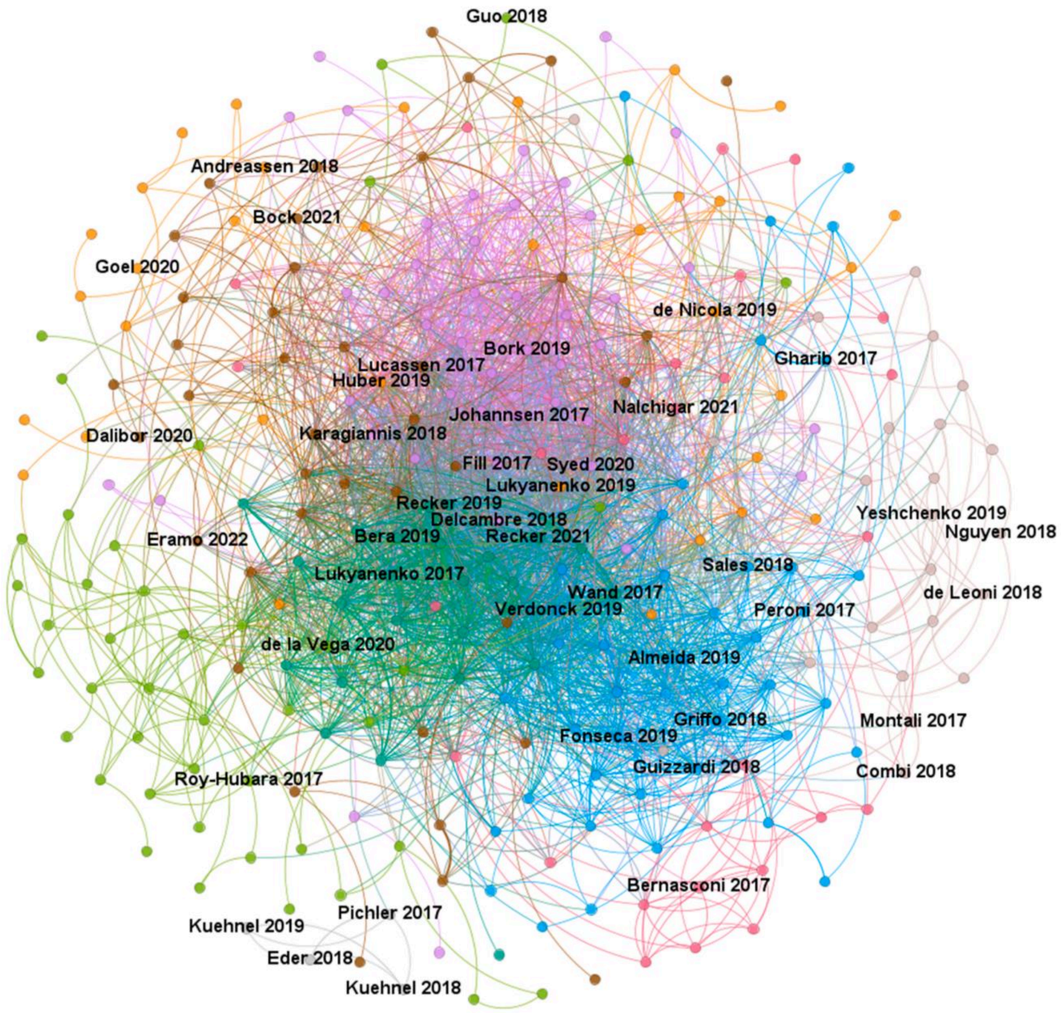
(green) Grammars and guidelines for conceptual modeling

(blue) Requirements engineering and IS design methodologies

(yellow) Ontology constructs for conceptual modeling

Unraveling the foundations and the evolution of conceptual modeling

- Domain-specific CM
- **Ontologies and applications**
- Data and databases: datastore, NoSQL, multimodel data
- Goal models and requirements engineering
- Applications with or without ontologies
- Applications to genomics and healthcare
- **Understanding CM**; theoretical developments
- Process model including process modeling, process mining
- Temporal or economic view of the field



Foundational ontologies in action

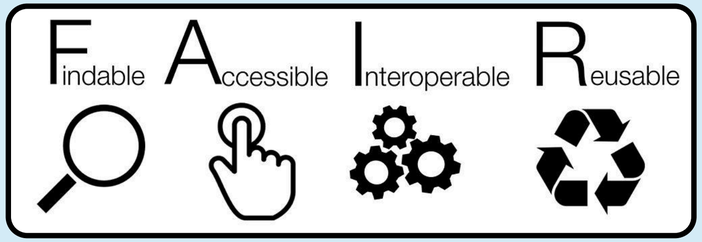
Borgo, Stefano | Galton, Antony | Kutz, Oliver
Applied Ontology, vol. 17, no. 1, pp. 1-16, 2022

1. BFO: Basic Formal Ontology
2. DOLCE: Descriptive Ontology for Linguistic and Cognitive Engineering
3. GFO: General Formal Ontology
4. GUM: Generalized Upper Model
5. TUpper: A Top Level Ontology within Standards
6. **UFO: Unified Foundational Ontology**
7. YAMATO: Yet Another More Advanced Top-level Ontology

1. UFO
a well-grounded foundational ontology based on contributions from Formal Ontology in Philosophy, Philosophical Logic, Cognitive Psychology, and Linguistics.

2. OntoUML
an ontology-driven conceptual modeling language that extends class diagrams in the UML by defining a set of stereotypes that reflect UFO ontological distinctions into language constructs.

3. FAIR Catalog



ONTOUML/UFO Catalog

The **FAIR Model Catalog** for Ontology-Driven Conceptual Modeling Research, commonly referred to as OntoUML/UFO Catalog, is a structured and open-source catalog that contains OntoUML and UFO ontology models. It was conceived to allow collaborative work and to be easily accessible to all its users.

The goal of the OntoUML/UFO Catalog is to support empirical research in OntoUML and UFO, as well as for the general conceptual modeling area, by providing high-quality curated, structured, and machine-processable data on why, where, and how different modeling approaches are used.

185 ODCMs

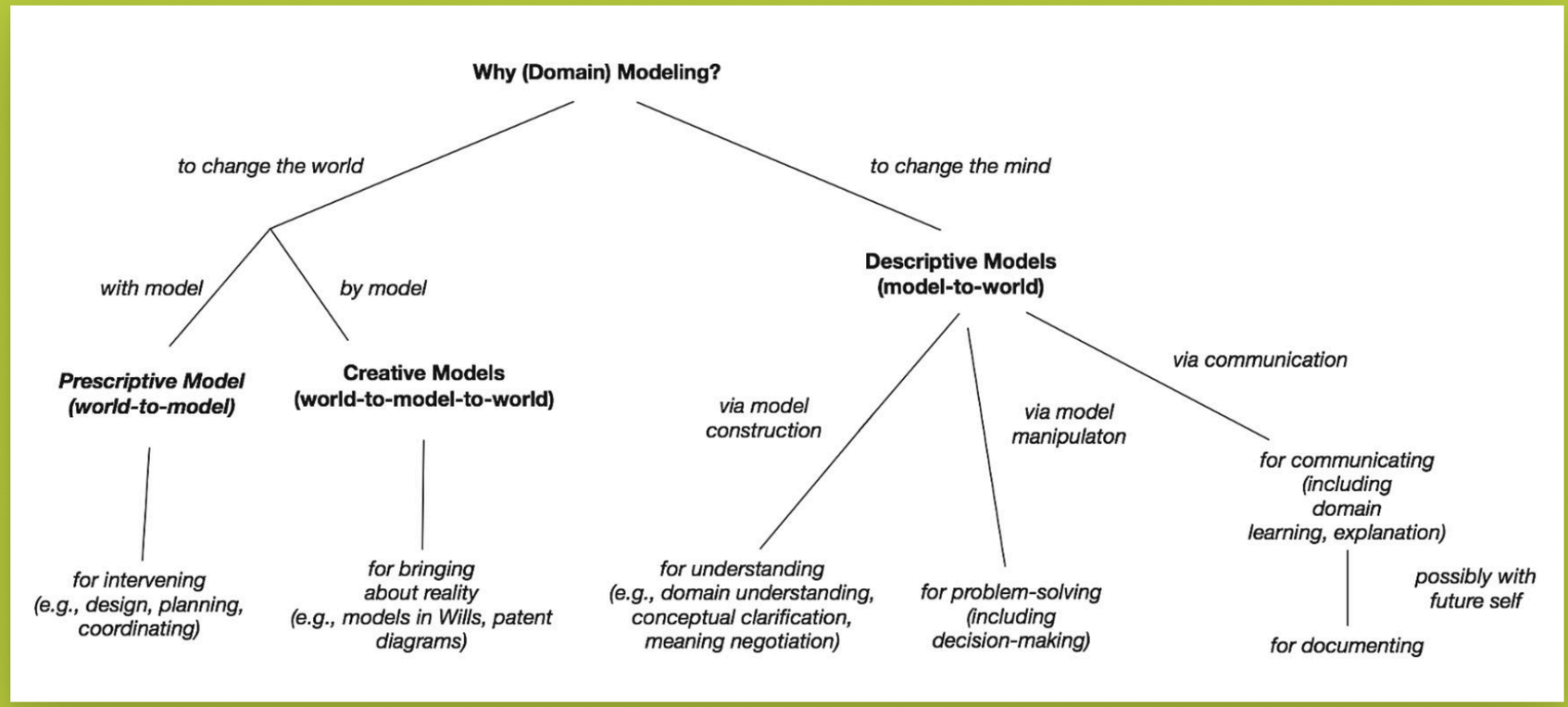
from 7 to 3760 classes

up to 1782 relations

issued from 2005 to 2024

Why we use CMs?

Intervening
Understanding
Problem-solving
Communicating
Documenting
Learning



Guizzardi, G., Proper, H.A.
On understanding the value of domain modeling.
In: 15th International Workshop on Value Modelling and Business Ontologies, pp.51-62 (2021)

Valle Sousa, et al.
What Do I Get from Modeling?
In: EDOC 2023. LNCS, vol 14367.

Why we use CMs?

Intervening
Understanding
Problem-solving
Communicating
Documenting
Learning

Do we use CMs?

YES

And even with the competency questions!

Monfardini, Glaice Kelly Q et al.
Use of Competency Questions in Ontology Engineering: A Survey.
In: Conceptual Modeling. vol. 14320. pp. 45-64 (2023)

Why we use CMs?

Intervening
Understanding
Problem-solving
Communicating
Documenting
Learning

Do we use CMs?

YES

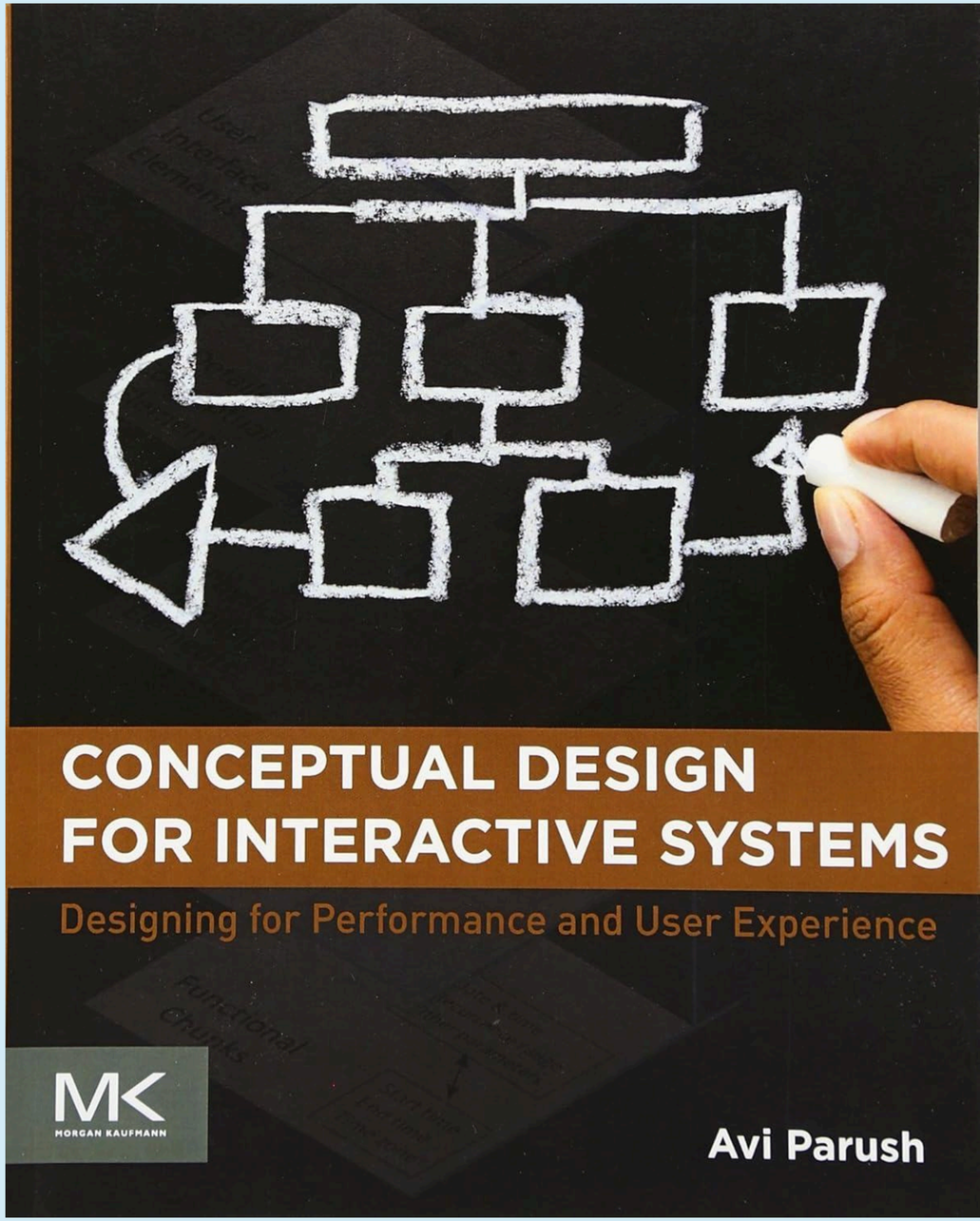
And even with the competency questions!

Do we reuse CMs?

“36.38% of the ontologies registered in LOV could not be appropriately loaded.”

Fernández-López, M. et al.
Why are ontologies not reused across the same domain?
Web semantics, 2019-08, Vol.57, p.100492

If you understand it, you can use it!



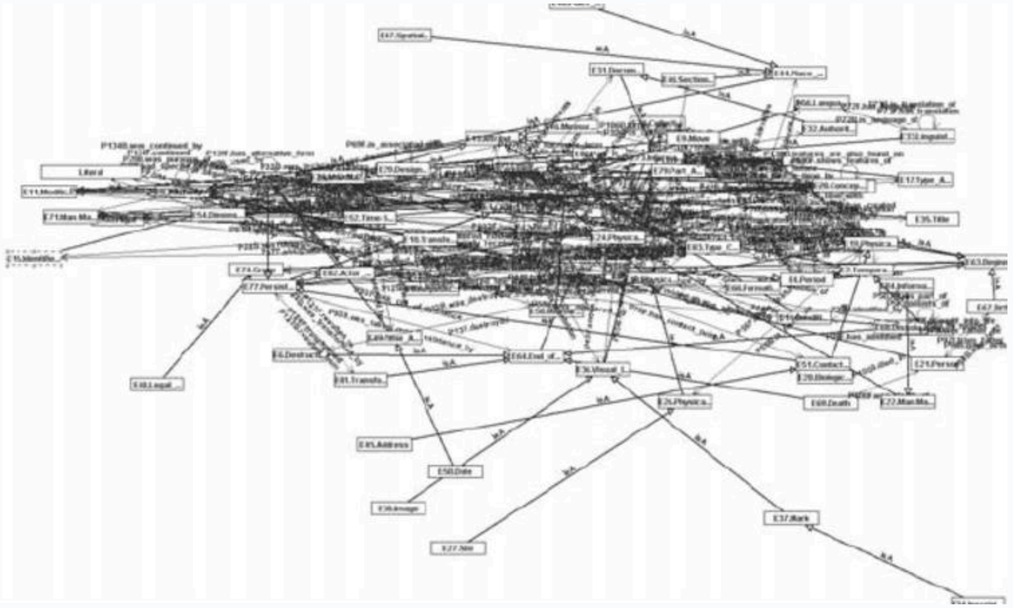
CIDOC Conceptual Reference Model

6 languages

Article Talk Read Edit View history Tools

From Wikipedia, the free encyclopedia

The **CIDOC Conceptual Reference Model** (**CRM**) provides an extensible ontology for concepts and information in cultural heritage and museum documentation. It is the international standard (ISO 21127:2023) for the controlled exchange of cultural heritage information.[1] Galleries, libraries, archives, museums (GLAMs), and other cultural institutions are encouraged to use the CIDOC CRM to enhance accessibility to museum-related information and knowledge.



Tzitzikas, Y., Kotzinos, D., Theoharis, Y.
On Ranking RDF Schema Elements (and its Application in Visualization)
Journal of Universal Computer Science 13(12), 1854-1880 (2007)

1.

understanding is a cognitive process, a process of abductive inference for ‘filling the gaps’

Chin-Parker, S., Bradner, A.
Background shifts affect explanatory style: how a pragmatic theory of explanation accounts for background effects in the generation of explanations.
Cogn. Process 11, pp. 227–249 (2010).

2.

interpretation is an opinion of what something means

Cambridge Dict.

Marques-Silva, J., Ignatiev, A.
No silver bullet: interpretable ML models must be explained
Front. Artif. Intell., vol. 6 (2023)

3.

scientific **explanation** may be regarded as an answer to a why-question

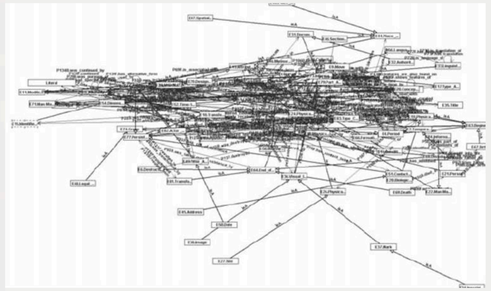
Hempel, C. G.
Aspects of scientific explanation
In: Aspects of scientific explanation and other essays in the philosophy of science.
2nd printed. Free press Collier-Macmillan, pp. 331–496.

understanding

“understanding is an intrinsic good provided by explanation”
(Lipton, P., 2004)

“understanding the world is the intellectual benefit we expect to acquire by constructing explanations”
(Weber, E., Van Bouwel, J., De Vreese, L., 2013)

interpretation



explanation

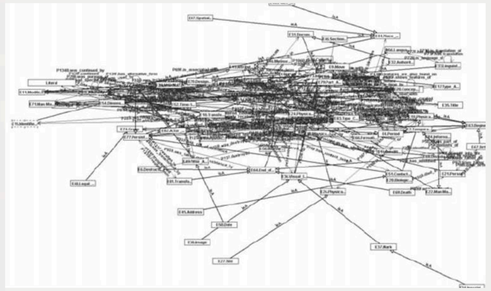
“explanations are the primary means by which people construct an understanding of the world”
(Horne, Z., Muradoglu, M., Cimpian, A., 2019.)

understanding

internal process

varies significantly from stakeholder to stakeholder

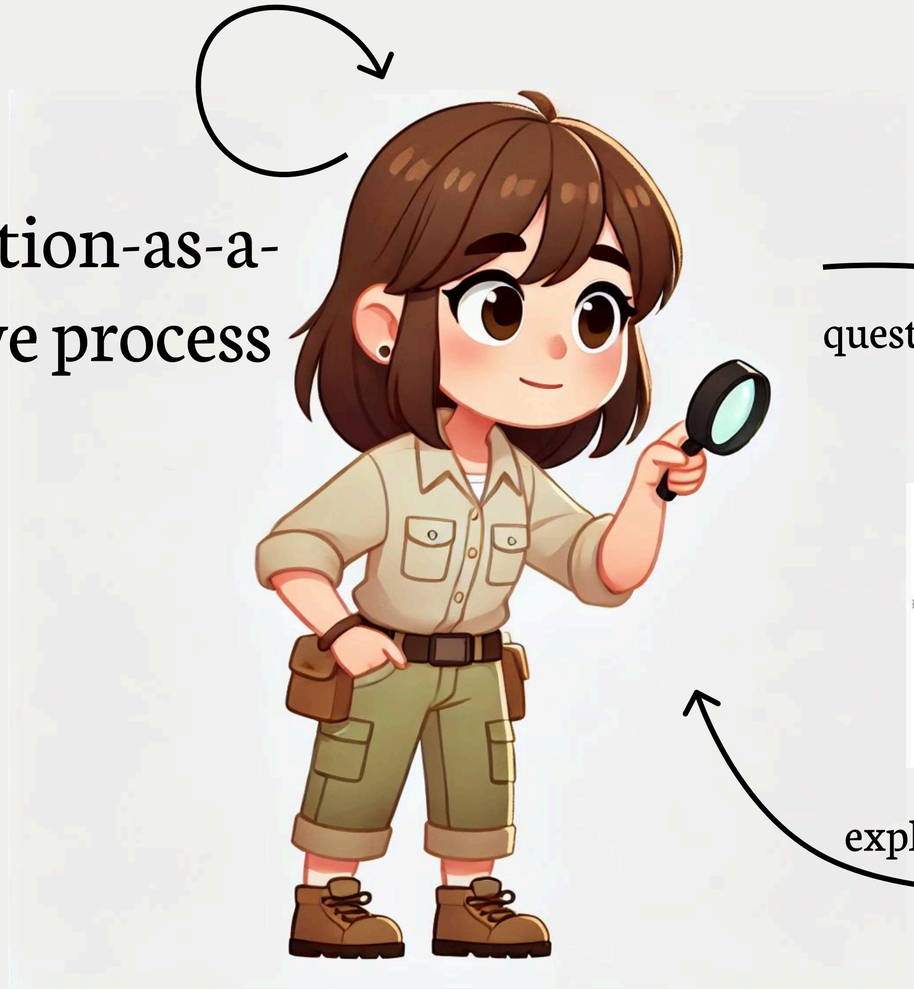
interpretation



explanation

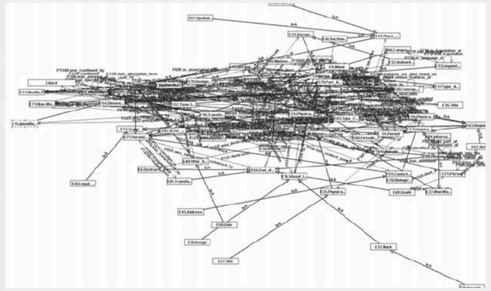
requires a question

explanation-as-a-cognitive process



explanation-as-a-social-process

question



explanation-as-a-product

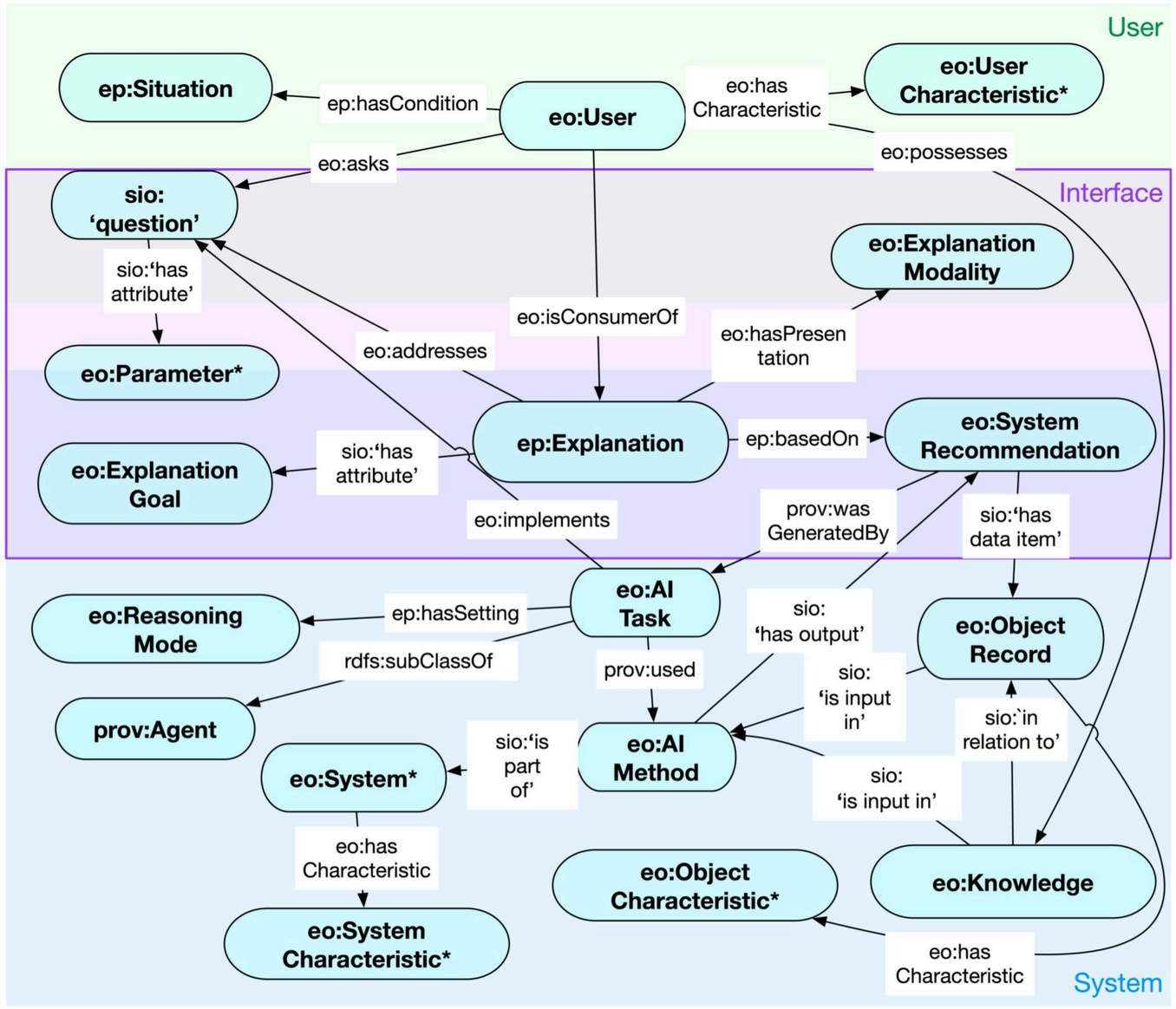
different forms:
diagram, formulas, text

explanation

Miller, T.
Explanation in artificial intelligence: Insights from the social sciences.
In: Artificial Intelligence 267, pp. 1–38 (2019)

Explanation Ontology

case based
contextual
contrastive
counterfactual
everyday
scientific
statistical
...



*Classes introduced in EO version 2.0

Key

Class

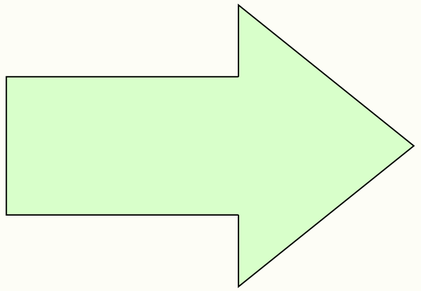
Connecting property

Prefixes

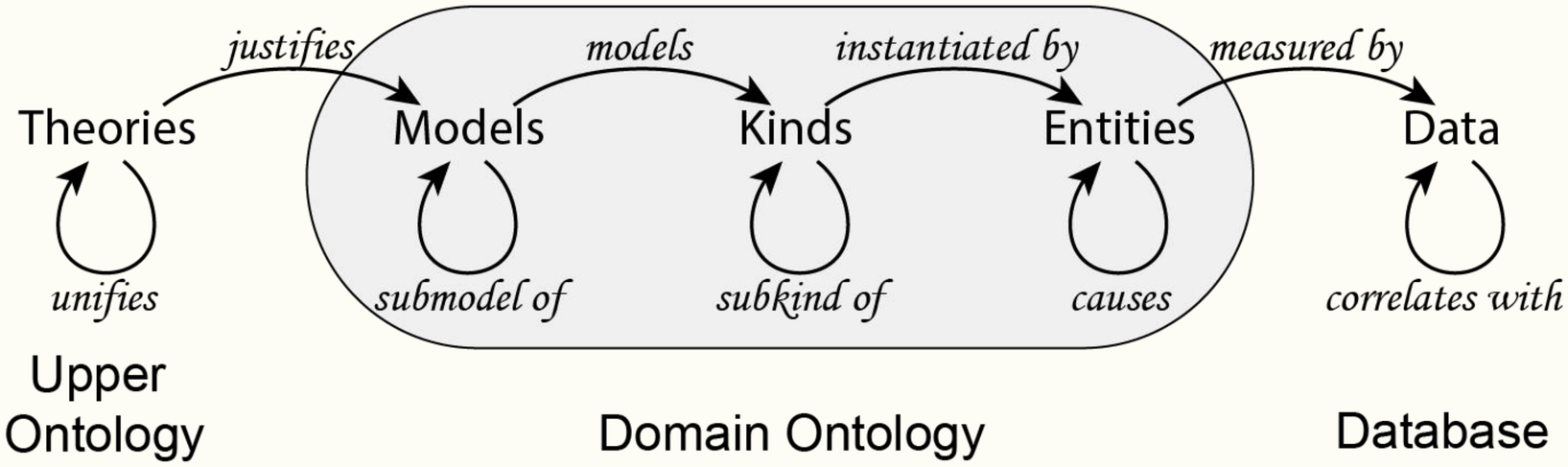
eo	Explanation Ontology
ep	Explanation Patterns Ontology
sio	SemanticScience Integrated Ontoogy
prov	Prov-O

PRAGMATIC APPROACH

1. Make context-dependent normative claims and argue for them.
2. Make context-dependent descriptive claims and argue for them.
3. Take into account the epistemic interests while doing this.



Romanenko, E., Calvanese, D., Guizzardi, G.
Towards Pragmatic Explanations for Domain Ontologies.
In: EKAW. Vol. 13514. LNCS, pp. 201–208 (2022)



An **explanation** of the ODCM with respect for a given question is an **ODCM view** sufficient to answer that question.

An **ODCM view** is a model obtained from the given one by applying one or more **explanation transformations** that preserve the consistency of the model.

How can we generate the questions?

1.

Competency Questions

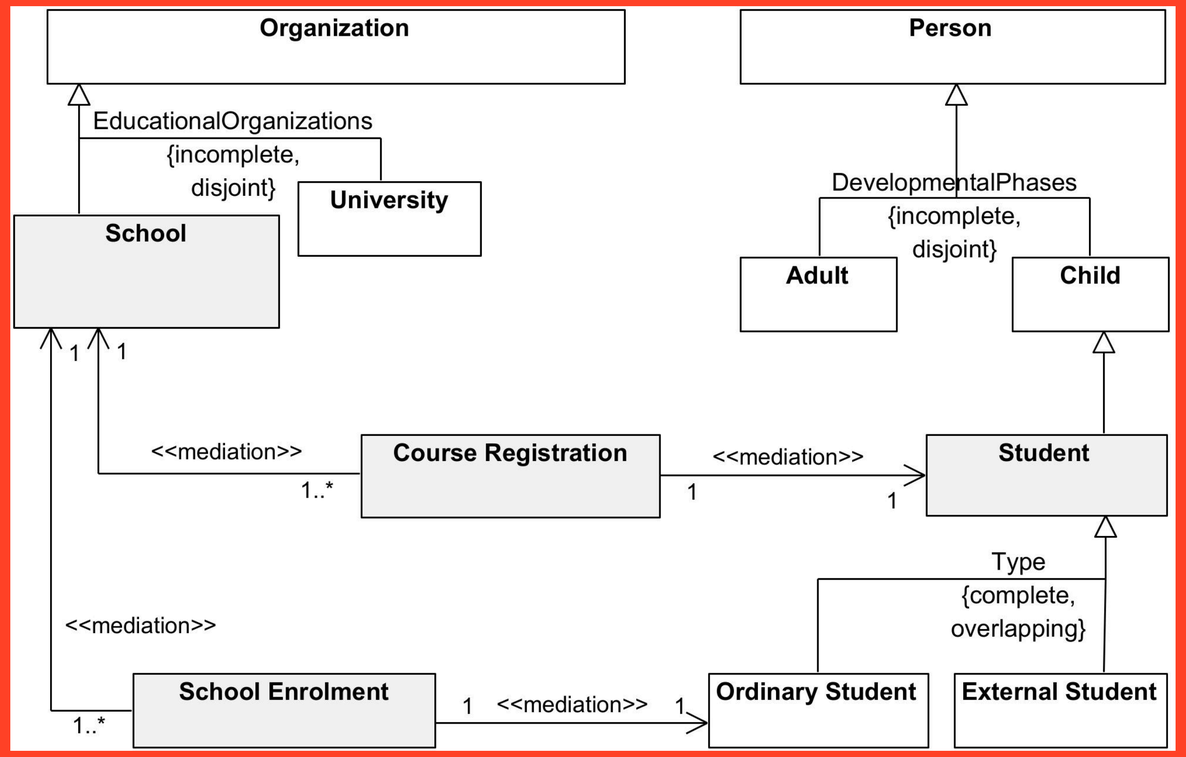
“one should construct the model so that these questions can be answered, and, to the extent possible, model no further than necessary to answer them”

Allemang, D., Hendler, J.
Chapter 14 - good and bad modeling practices.
In: Semantic Web for the Working Ontologist, pp. 307–324 (2011)

How can we generate the questions?

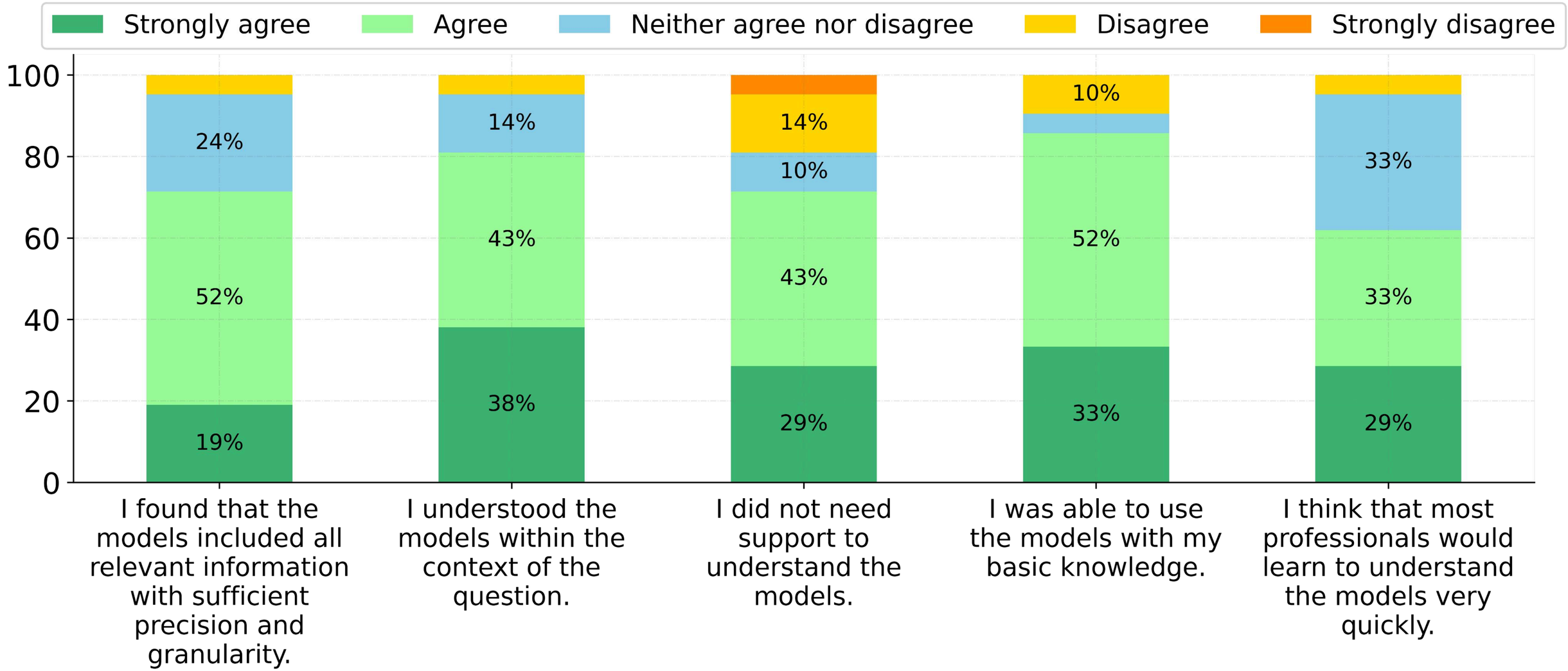
1. Competency Questions

2. Pattern-based Approach



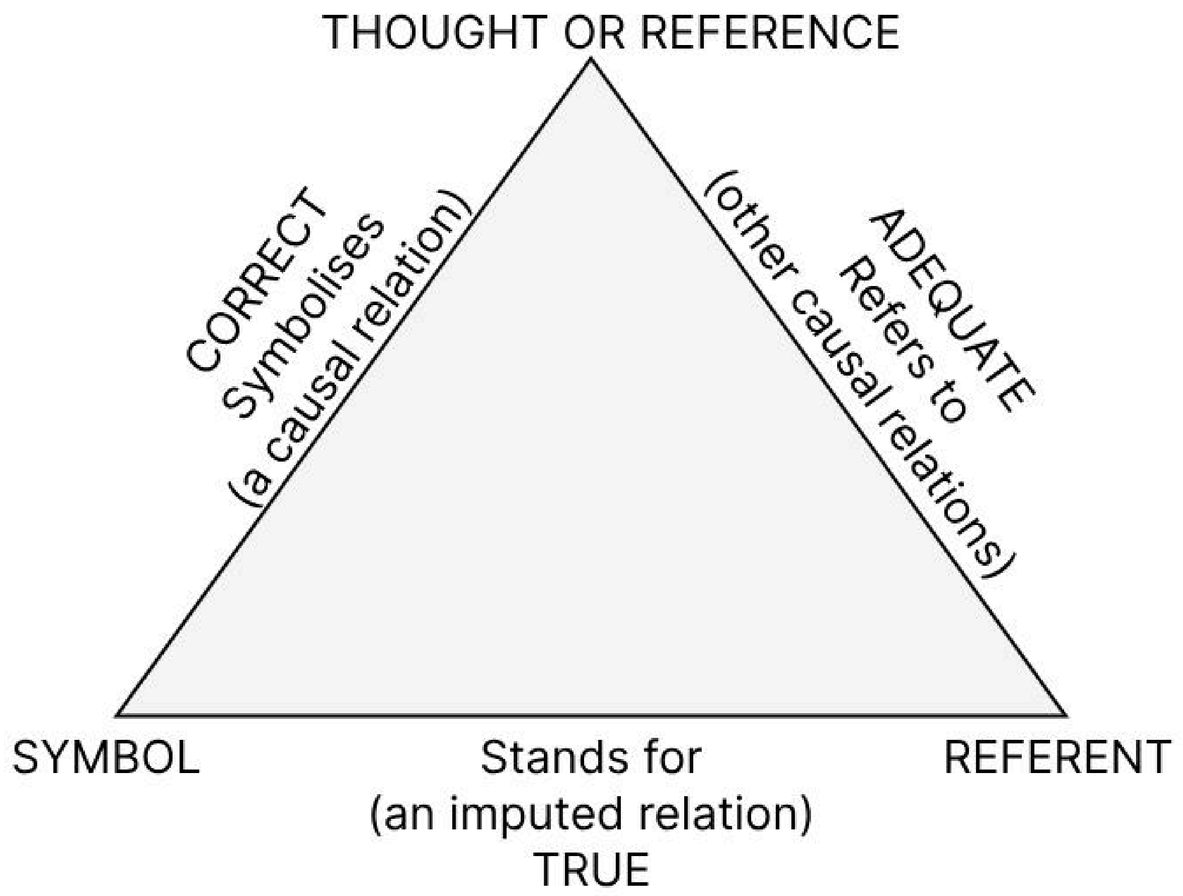
Can the Student be an Ordinary student and an External student at the same time?

Yes, even if the Student has Enrolment in one School, he can be an External Student in another School.


Strongly agree
Agree
Neither agree nor disagree
Disagree
Strongly disagree
100
80
60
40
20
0
24%
52%
19%
14%
43%
38%
14%
10%
43%
29%
10%
52%
33%
33%
33%
29%
I found that the models included all relevant information with sufficient precision and granularity.
I understood the models within the context of the question.
I did not need support to understand the models.
I was able to use the models with my basic knowledge.
I think that most professionals would learn to understand the models very quickly.

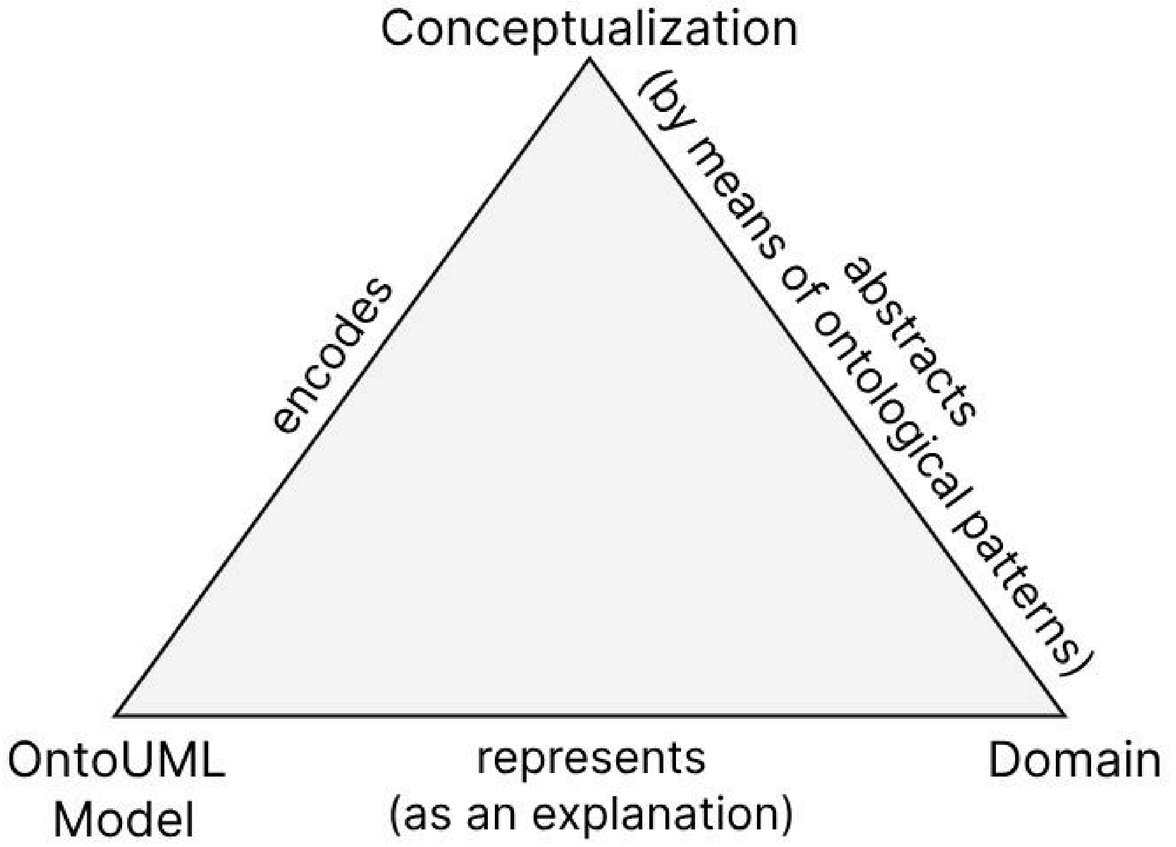
EXPLAINING AN EXPLANATION

ABSTRACTING AN ABSTRACTION



THE TRIANGLE OF REFERENCE

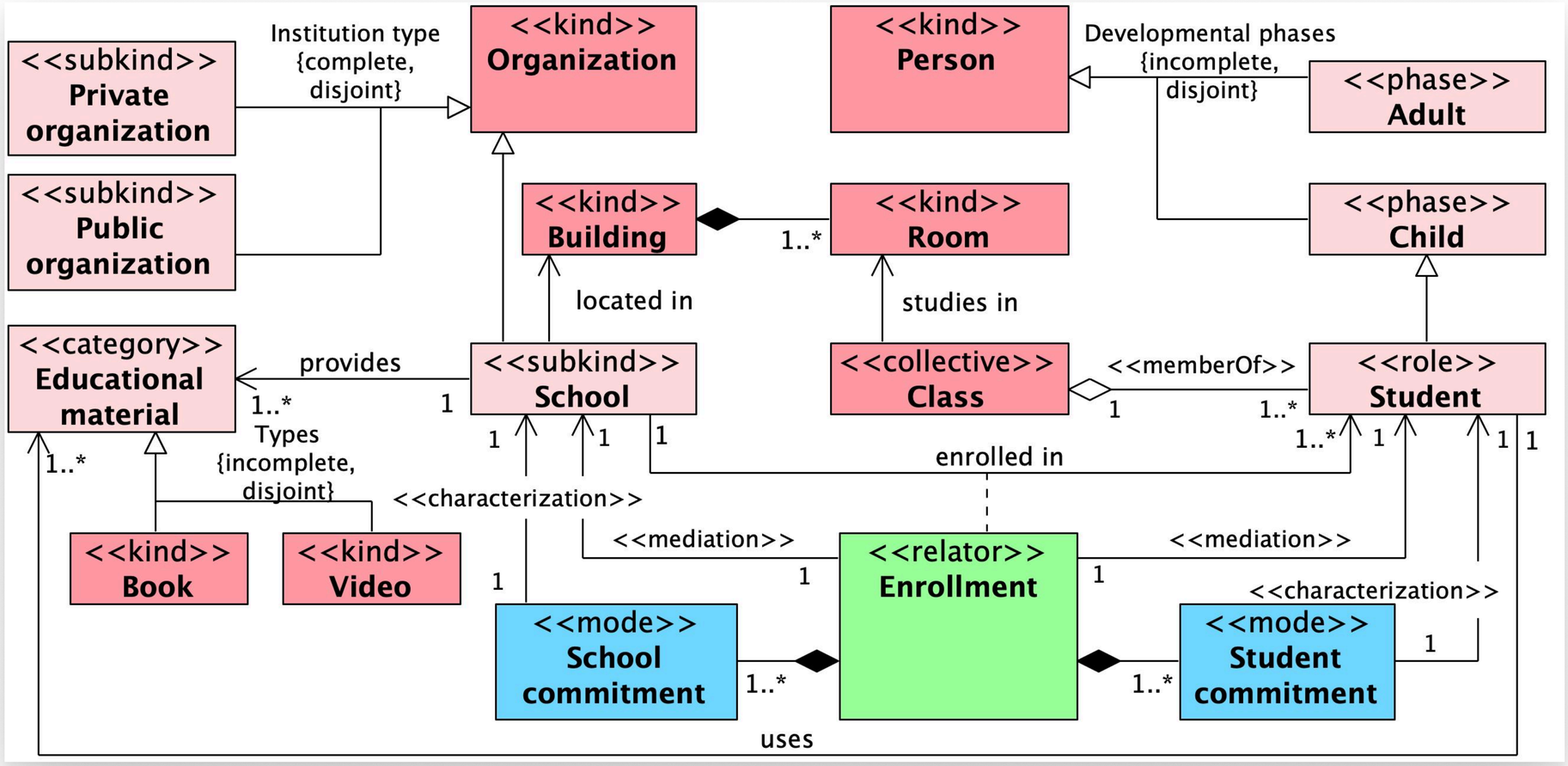
Ogden, C. K., Richards, I.A. Meaning of Meaning. (1989)



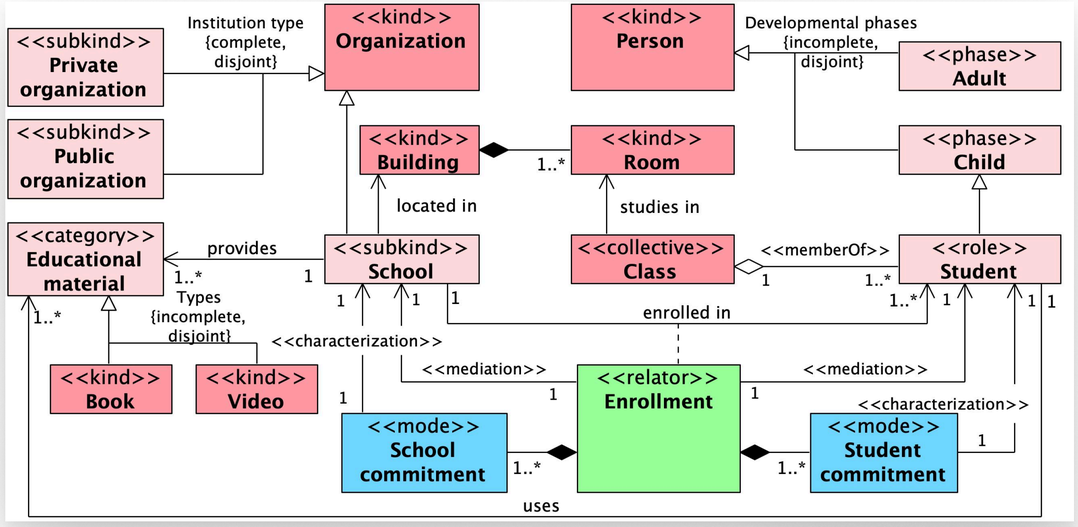
INTERPRETATION OF THE TRIANGLE OF REFERENCE FOR THE CONCEPTUAL MODELING CASE

Abstraction can be a part of the explanation process

Romanenko, E., Calvanese, D., Guizzardi, G.
Evaluating quality of ontology-driven conceptual models abstractions.
In: Data & Knowledge Engineering 153, p. 102342.

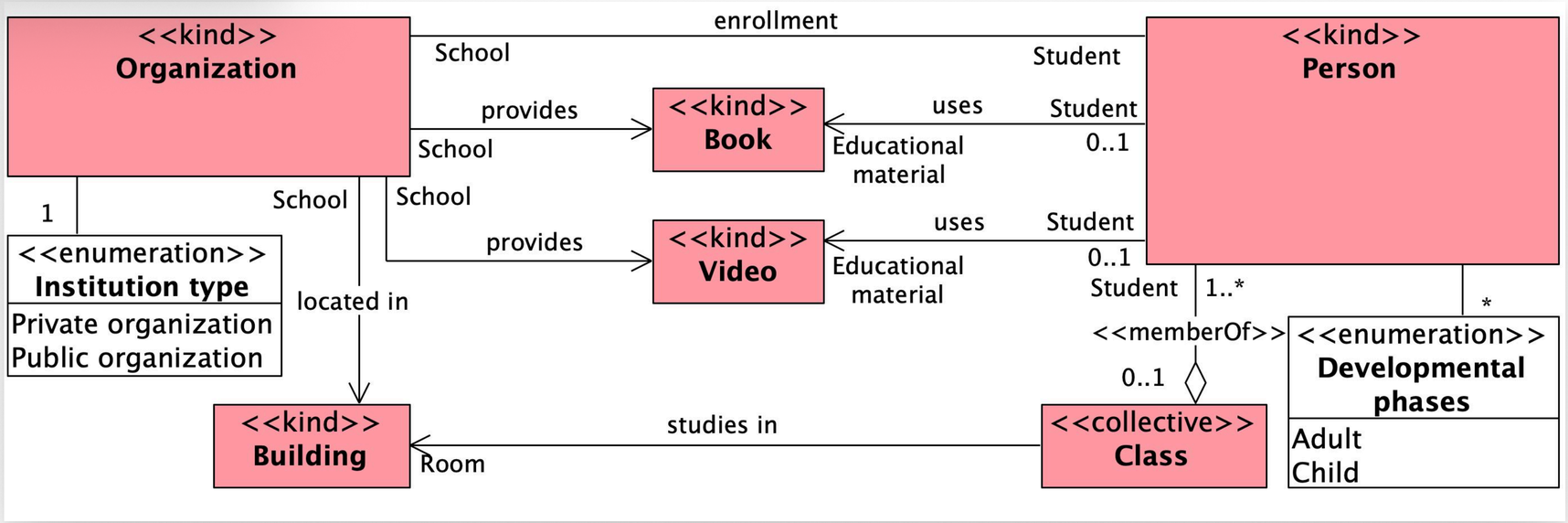


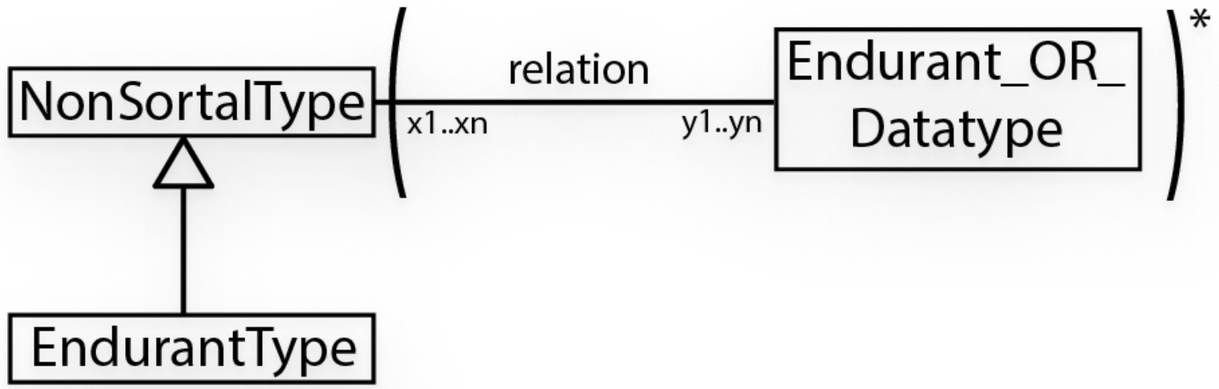
ORIGINAL MODEL



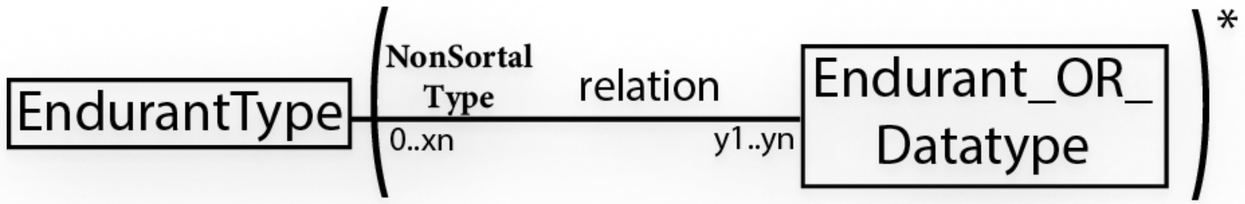
ORIGINAL MODEL

ABSTRACTED MODEL





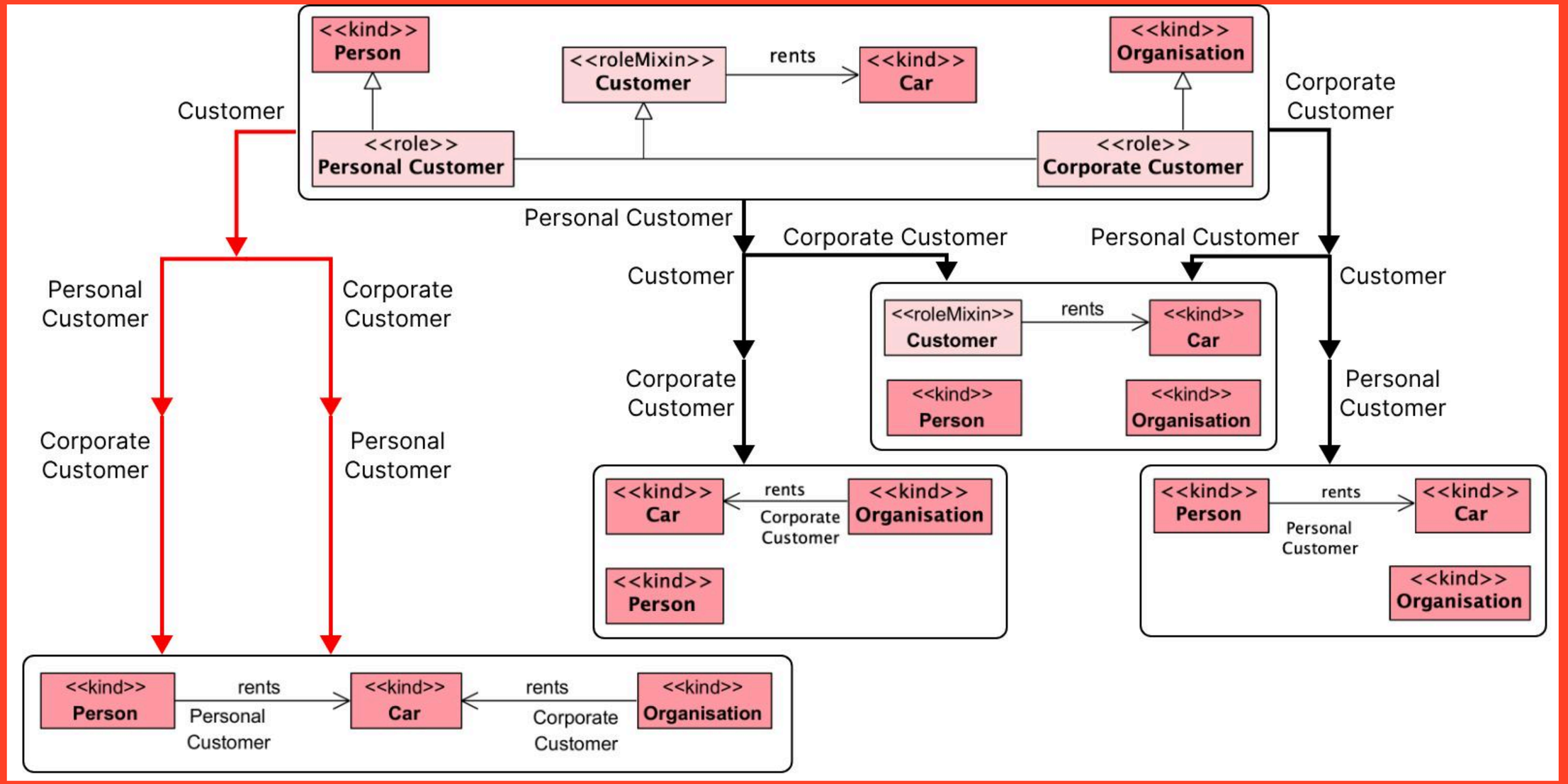
ORIGINAL MODEL



REPLACEMENT

Abstraction algorithm leveraging the semantics of UFO

1. Extended version
2. 11 rules
3. No seeding
4. Rules are in fact patterns
5. Allows the appearance of hierarchies



Romanenko, E. et al.

Towards Semantics for Abstractions in Ontology-Driven Conceptual Modeling.

In: Proc. of the ER 2023 Workshops (OntoCom). Vol. 14319. LNCS, pp. 199–209.

Abstraction of conceptual models as a weakening process

ABSTRACTION

Abstraction is a mapping from a **ground** (original) to an **abstracted** (intended) space
(Saitta & Zucker, 2013)

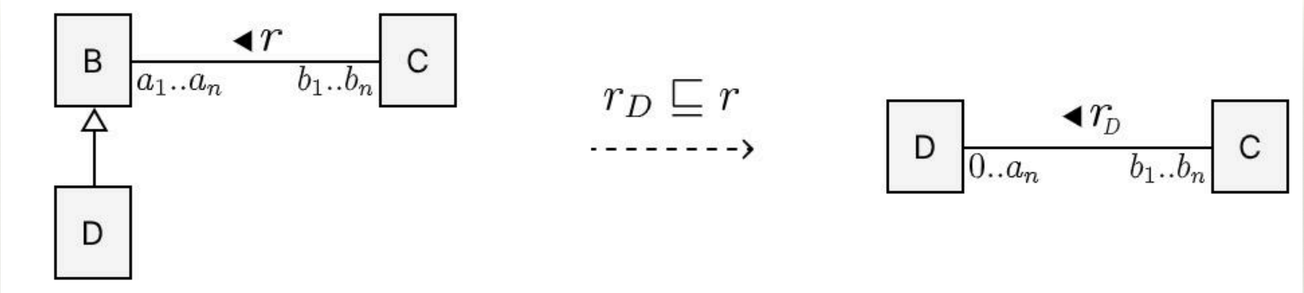
- Plaisted, D.A.: Theorem proving with abstraction. Artificial intelligence 16(1), 47–108 (1981)
- Hobbs, J.R.: Granularity. In: Proc. of the 9th IJCAI, vol. 1, 432–435 (1985)
- Tenenberg, J.D.: Preserving consistency across abstraction mappings. In: Proc. of the 10th IJCAI, 1011–1014 (1987)
- **Giunchiglia, F., Walsh, T.: A theory of abstraction. Artificial intelligence 57(2), 323–389 (1992)**
- Nayak, P.P., Levy, A.Y.: A semantic theory of abstractions. In: Proc. of the 14th IJCAI, vol. 1, 196–202 (1995)
- Ghidini, C., Giunchiglia, F.: A semantics for abstraction. In: Proc. of the 16th ECAI, 338-342 (2003)

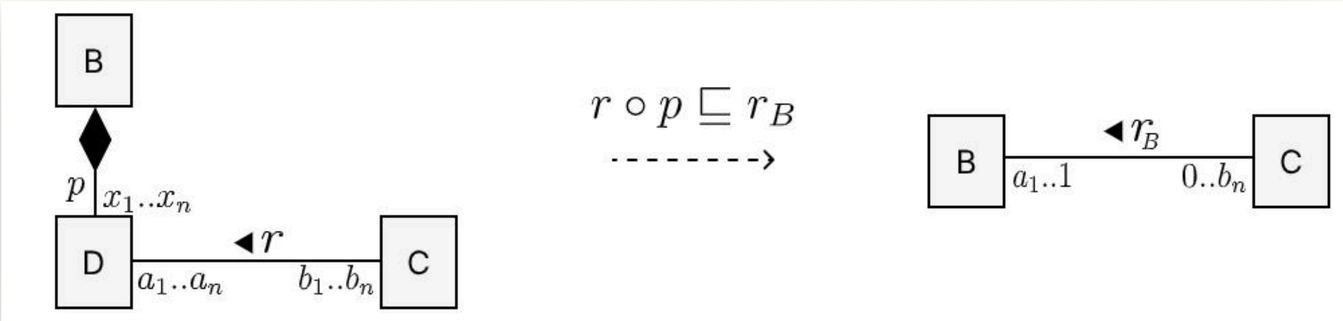
$$\mathfrak{T}_1 \models \mathfrak{T}_2$$

Axiom weakening is an approach that repairs ontologies by making axioms less restrictive.

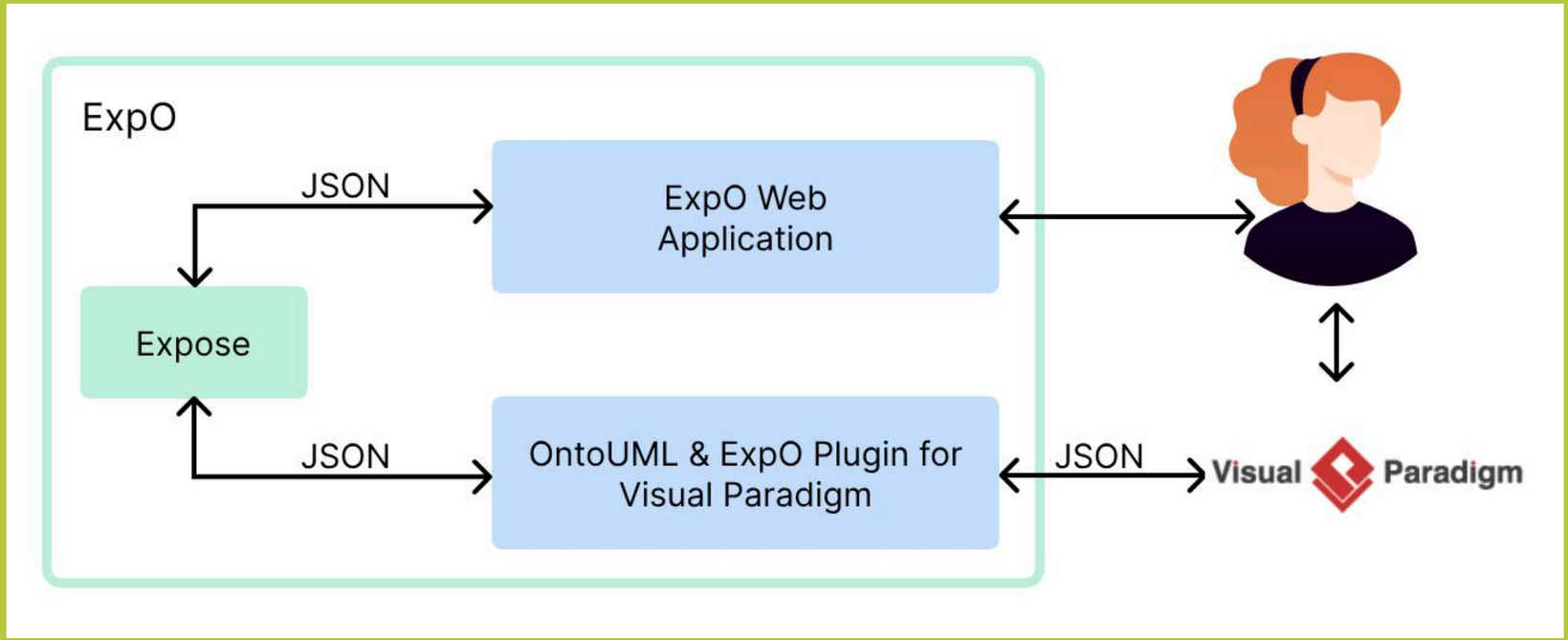
With some assumptions, abstraction can be considered as a weakening procedure

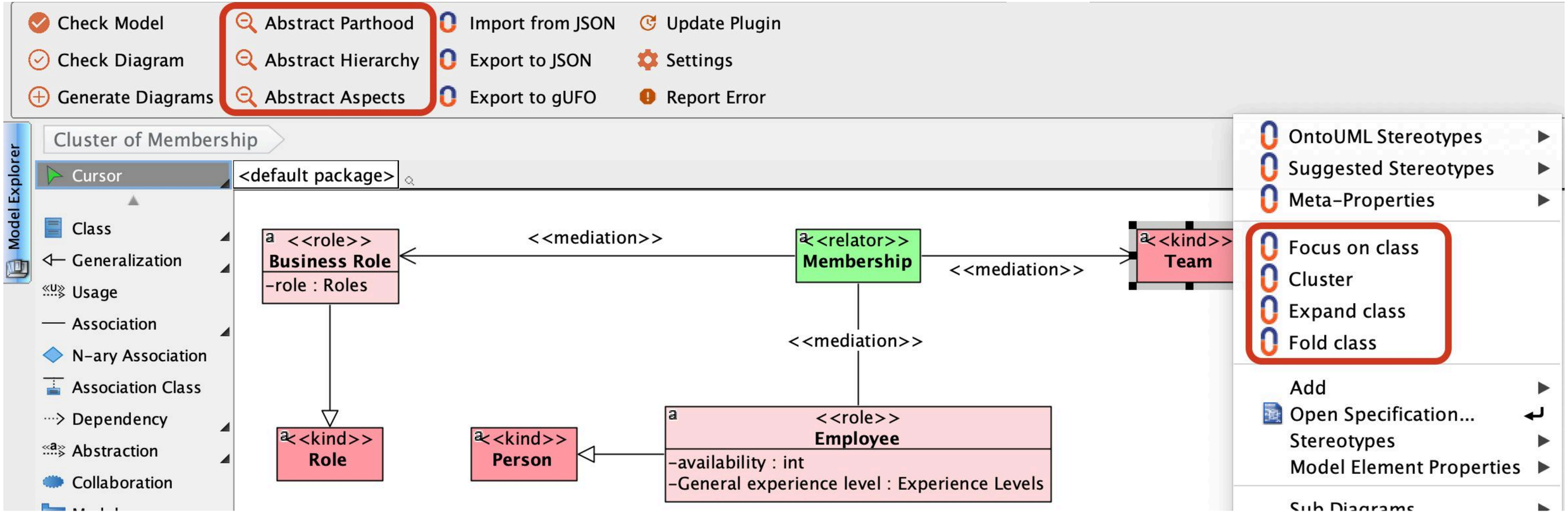
$$\mathfrak{T}_1 \oplus \mathfrak{T}_A \models \mathfrak{T}_2$$



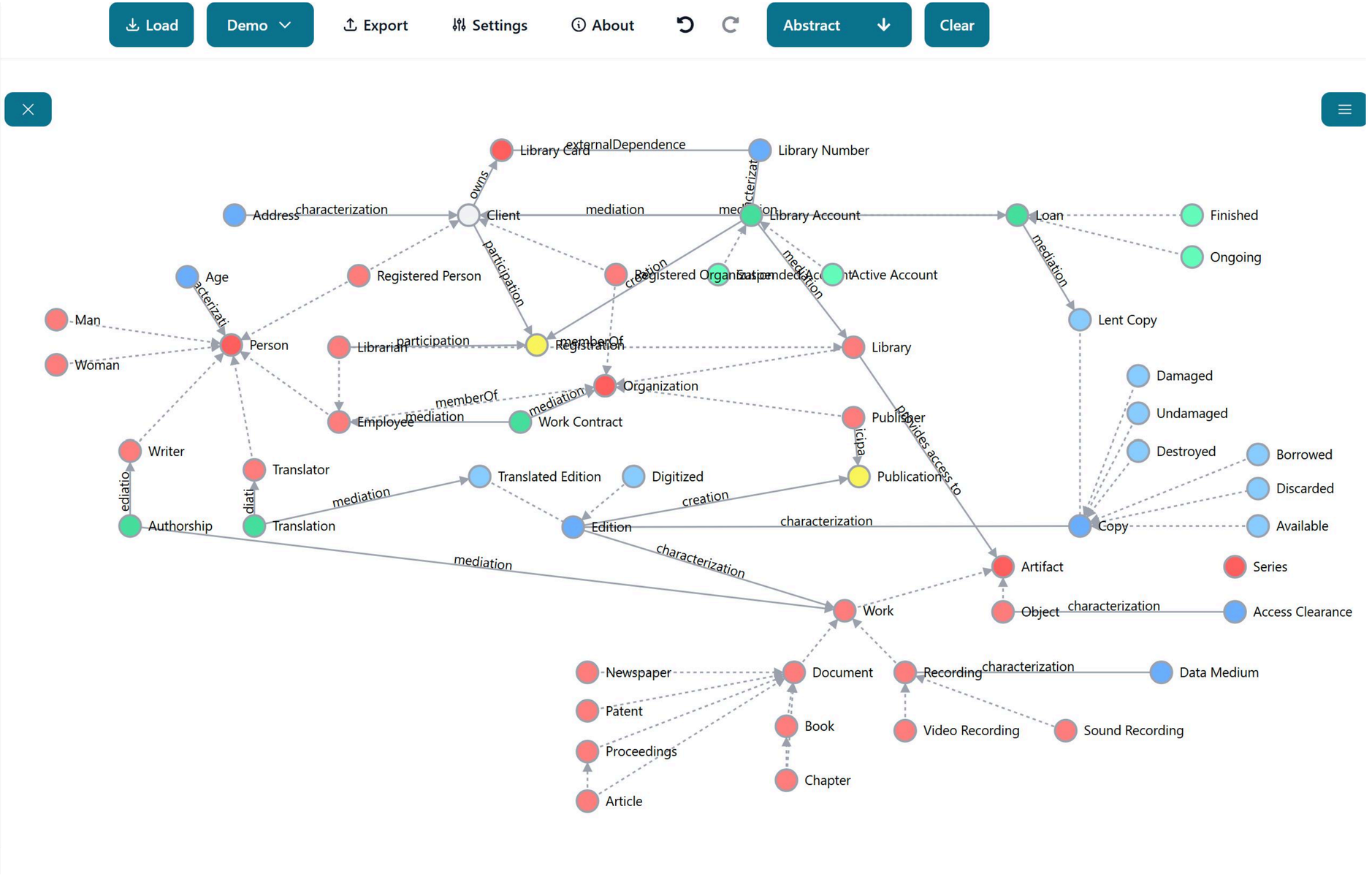


Please, meet ExpO prototype





ONTOUML & EXPO PLUGIN FOR VISUAL PARADIGM



EXPO WEB APPLICATION: HTTPS://W3ID.ORG/EXPO

Future directions

1. abstractions generated by GNNs
2. explanation as a weakening procedure
3. adaptation for the cases when the seeding is given

THANK YOU FOR YOUR ATTENTION