GRIIS

The Interconnections of Meanings in Ontology

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SCOR Online Seminar

Swiss Center for Ontological Research

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Sense and Reference

G. Frege, On Sense and Reference, 1892

Reference:
Portion of reality

Sense:
Cognitive significance

"internalist" conceptions of meaning

Linguistic expression

"evening star"

"morning star"

Meaning and reference of an ontological term

Ontological terms are introduced to share meaning between agents.

The goal is that in every possible circumstances, agents use terms to point to the same reference.

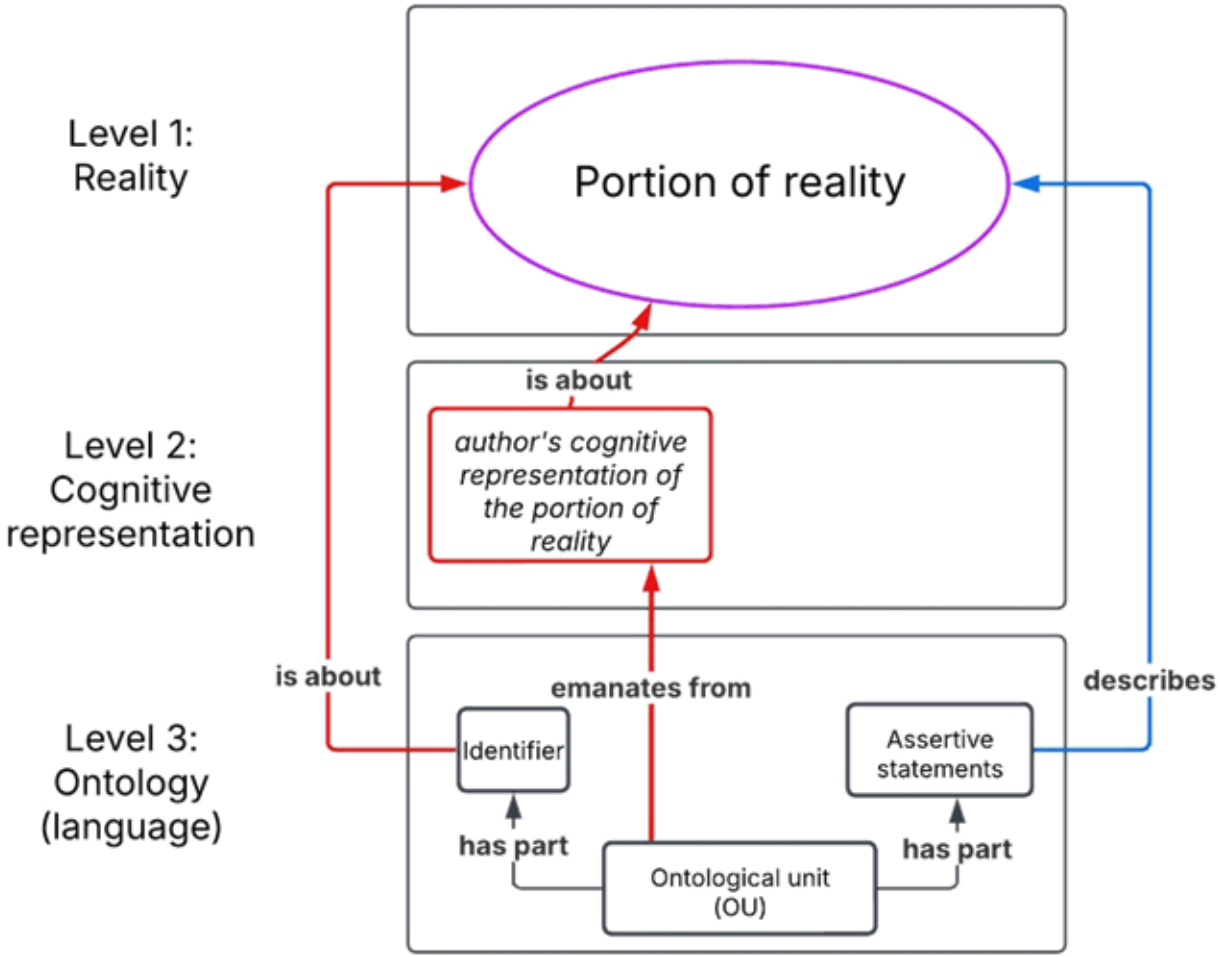
But there are limitations to this:

- P1: Practical problem: Expression of meaning and intended reference can be misaligned
- P2: Theoretical problem: Exact references of terms are impossible to determine because of the interconnections of terms' meanings.

P1: Misalignment of expressed meaning and intended reference

Ceusters, W. & Smith, B. (2015) Aboutness: Towards Foundations for the Information Artifact Ontology. Proceedings of the Sixth International Conference on Biomedical Ontology (ICBO), CEUR vol. 1515, p. 1–5.

Fabry, P., Barton, A., & Ethier, J. F. (2023). Version control for interdependent ontologies: challenges and first propositions. In *International Conference on Biomedical Ontology (ICBO 2023)*



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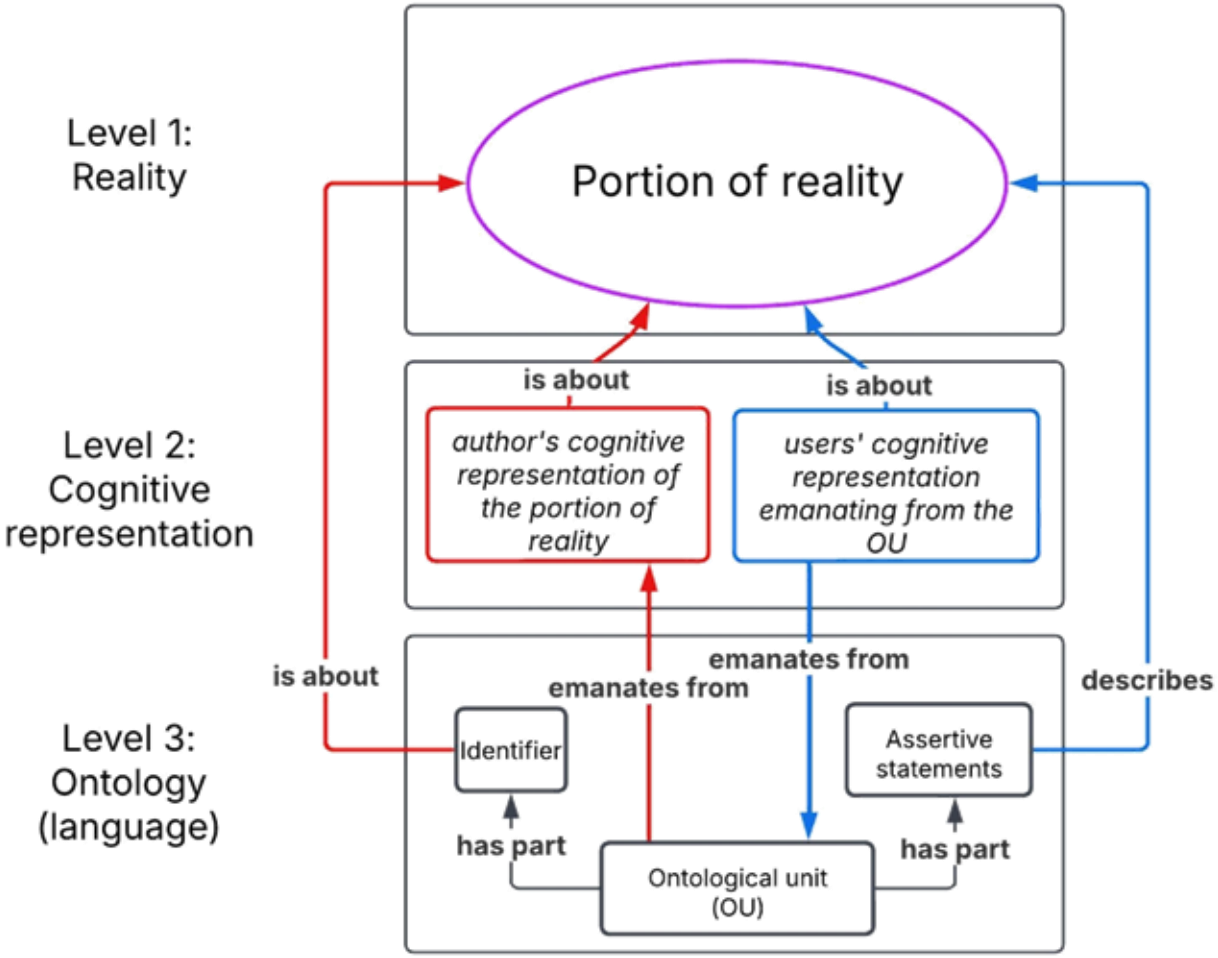
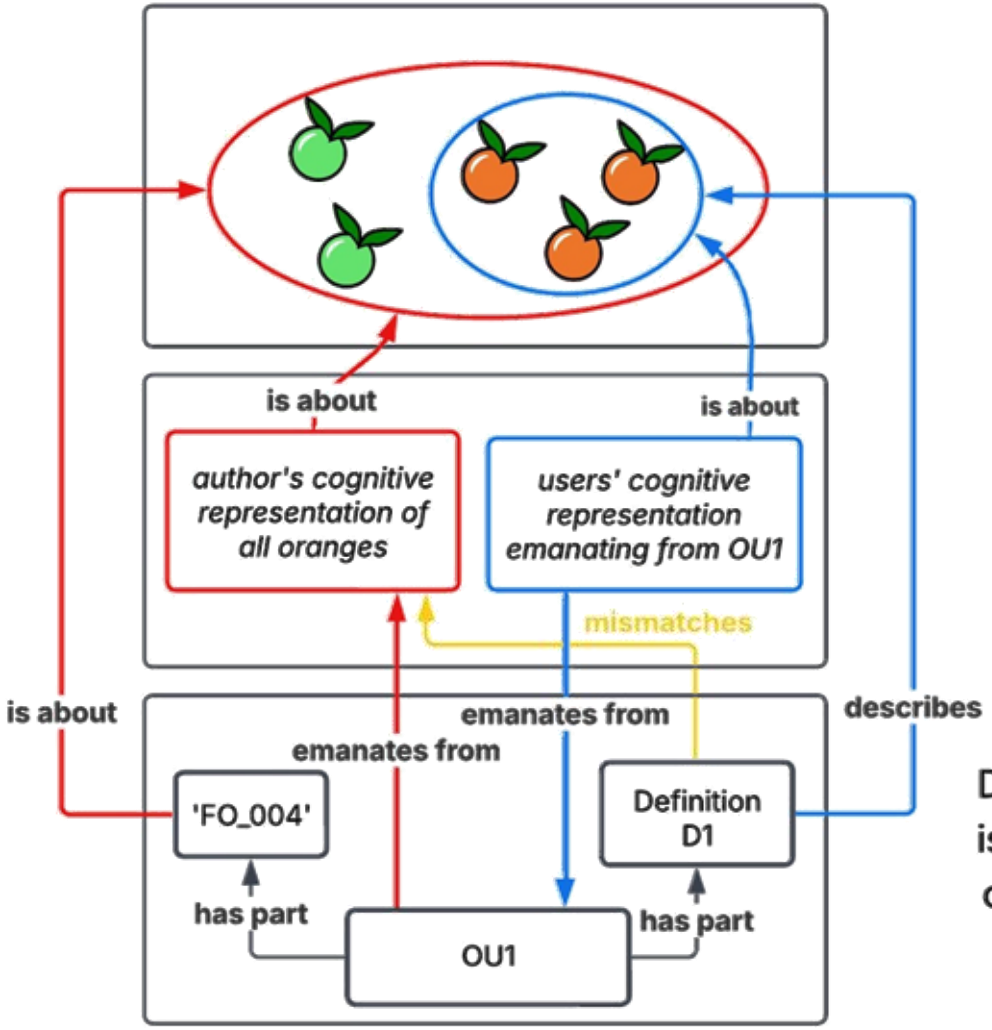
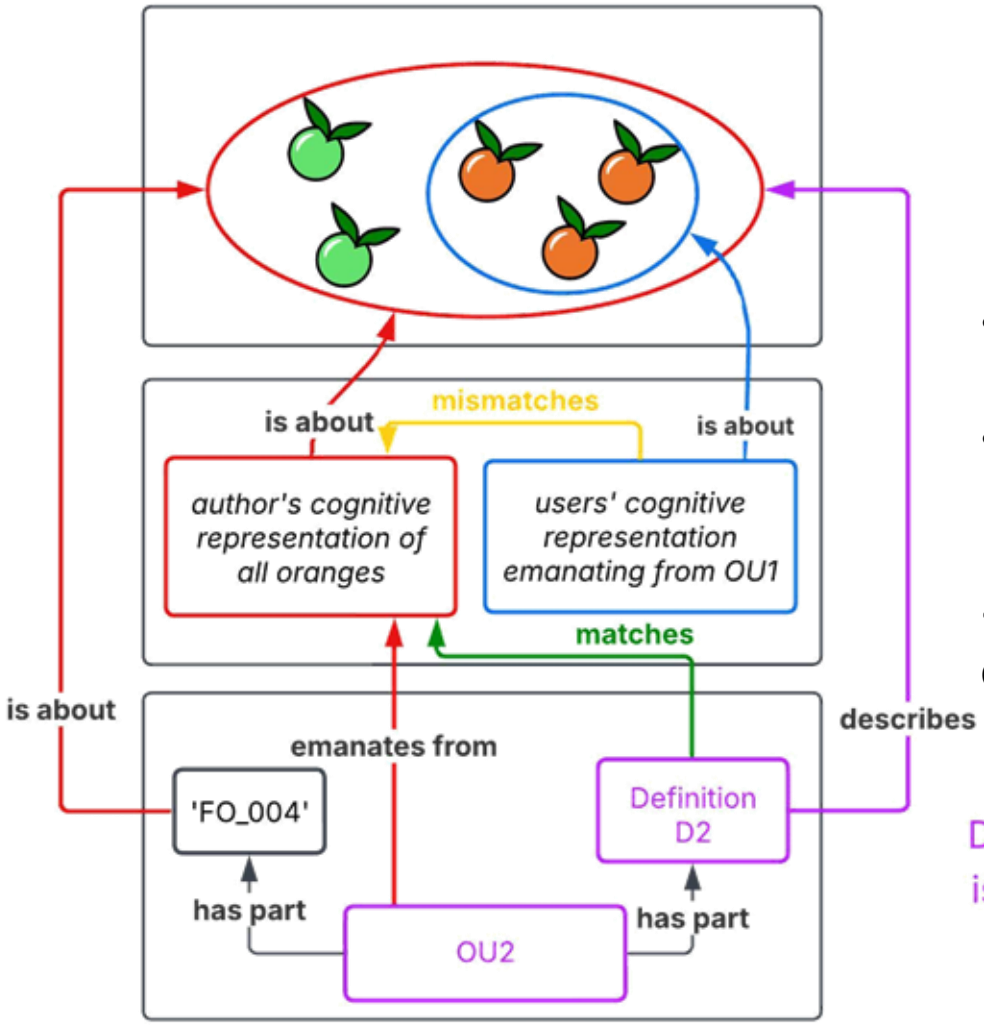


P1: Example: Fruit Ontology (FO)



D1: "A citrus fruit which is the edible fruit of the orange tree and that is orange in color."

P1: Example: Fruit Ontology (FO)



- How could we devise a better versioning system?
- When does the identity of an ontological unit change?

→ When should its identifier change?

D2: "A citrus fruit which is the edible fruit of the orange tree."

P2: Indeterminacy of reference

Different agents may assign different references to a term in a language.

Mary's interpretation of "table"

John's interpretation of "table"

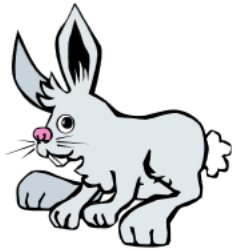
Mary

John

To make it explicit, maybe we could point to a nightstand and utter "table" or "not table"?

P2: Indeterminacy of reference

W. V. O. Quine, *Word and Object* (1960)



What does “Gavagai” refer to?

- the rabbit?
- a part of the rabbit?
- the history of the rabbit?
- a suggestion for dinner?

Various assignments of reference to words are compatible with the empirical evidence concerning speakers of a language.
This problem also appears in ontology.

Meaning holism

Jackman, H. (2020), Meaning Holism. *The Stanford Encyclopedia of Philosophy* (Winter 2020 Edition), Edward N. Zalta (ed.)

- Indeterminacy of reference is a consequence of meaning holism.

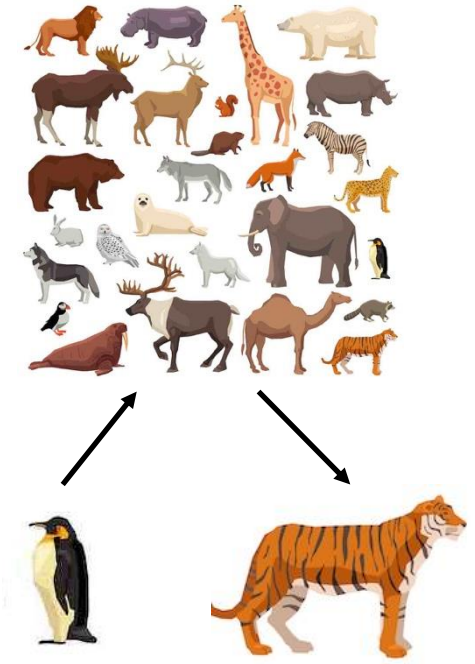
- (H) “The determinants of the meanings of our terms are interconnected in a way that leads a change in the meaning of any single term to produce a change in the meanings of each of the rest.”

- If you change the meaning of “penguin”,

it changes the meaning of “animal”,

and thus it changes the meaning of “tiger”.

- Adding any new term or altering the meaning of any existing term within an ontology would change the meanings of all terms within the ontology.



A big problem for interconnected sets of ontology

Example: the OBO Foundry

Download table as: [YAML | JSON-LD | RDF/Turtle]

bfo	Basic Formal Ontology (CC BY)	The upper level ontology upon which OBO Foundry ontologies are built. Detail	
chebi	Chemical Entities of Biological Interest (CC BY)	A structured classification of molecular entities of biological interest focusing on 'small' chemical compounds. Detail	
doid	Human Disease Ontology (PUBLICDOMAIN)	An ontology for describing the classification of human diseases organized by etiology. Detail	
go	Gene Ontology (CC BY)	An ontology for describing the function of genes and gene products Detail	
obi	Ontology for Biomedical Investigations (CC BY)	An integrated ontology for the description of life-science and clinical investigations Detail	
pato	Phenotype And Trait Ontology (CC BY)	An ontology of phenotypic qualities (properties, attributes or characteristics) Detail	
po	Plant Ontology (CC BY)	The Plant Ontology is a structured vocabulary and database resource that links plant anatomy, morphology and growth and development to plant genomics data. Detail	

Questions adressed in this talk

Q1) How can we define meaning and its specification in applied ontologies, using possible worlds semantics?

Q2) What is the extent of meaning holism, compared to its characterization in (H)?

Outline

Part I: **Introducing intended meaning and meaning specification**

Part II: **The analytic/synthetic distinction**

Part III: **The limits of meaning holism**

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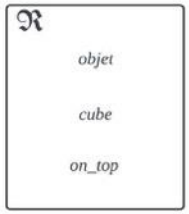

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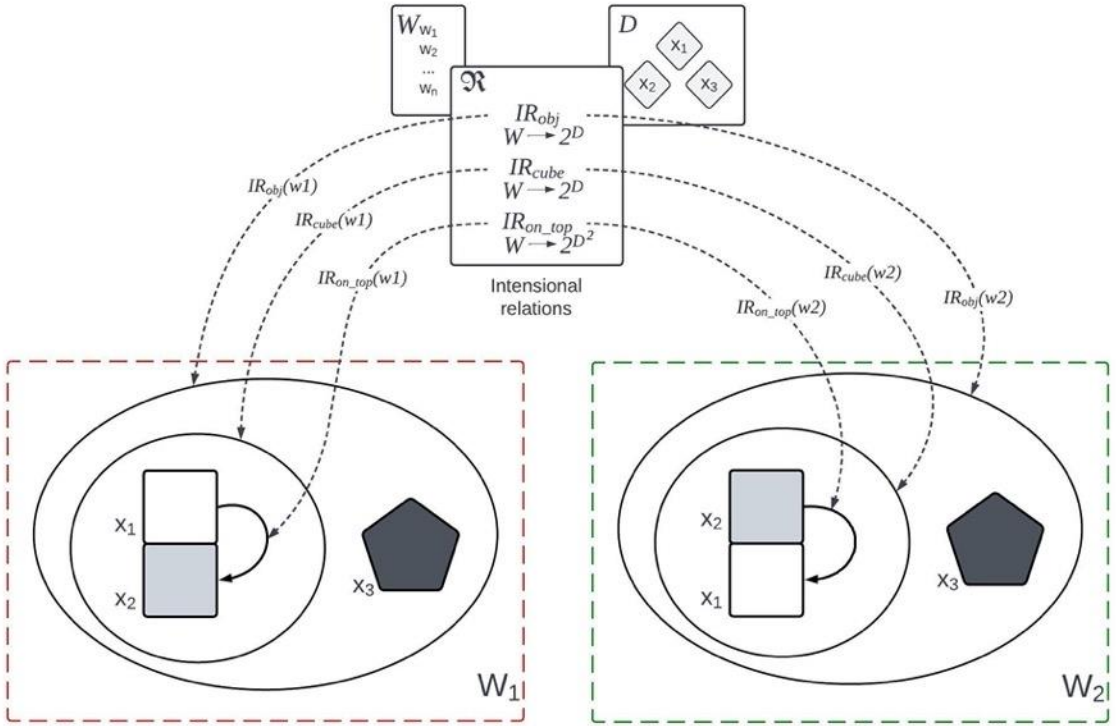

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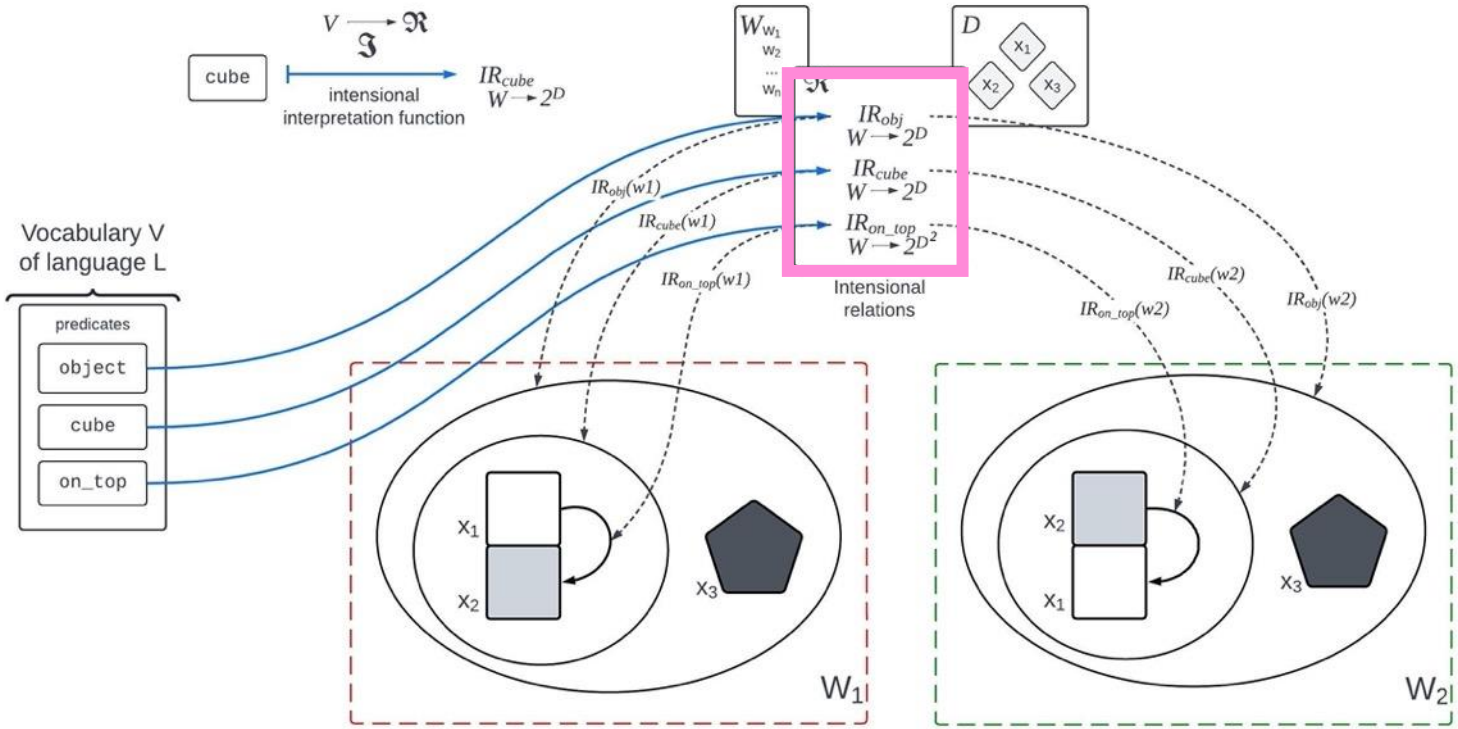
(Intended) meaning



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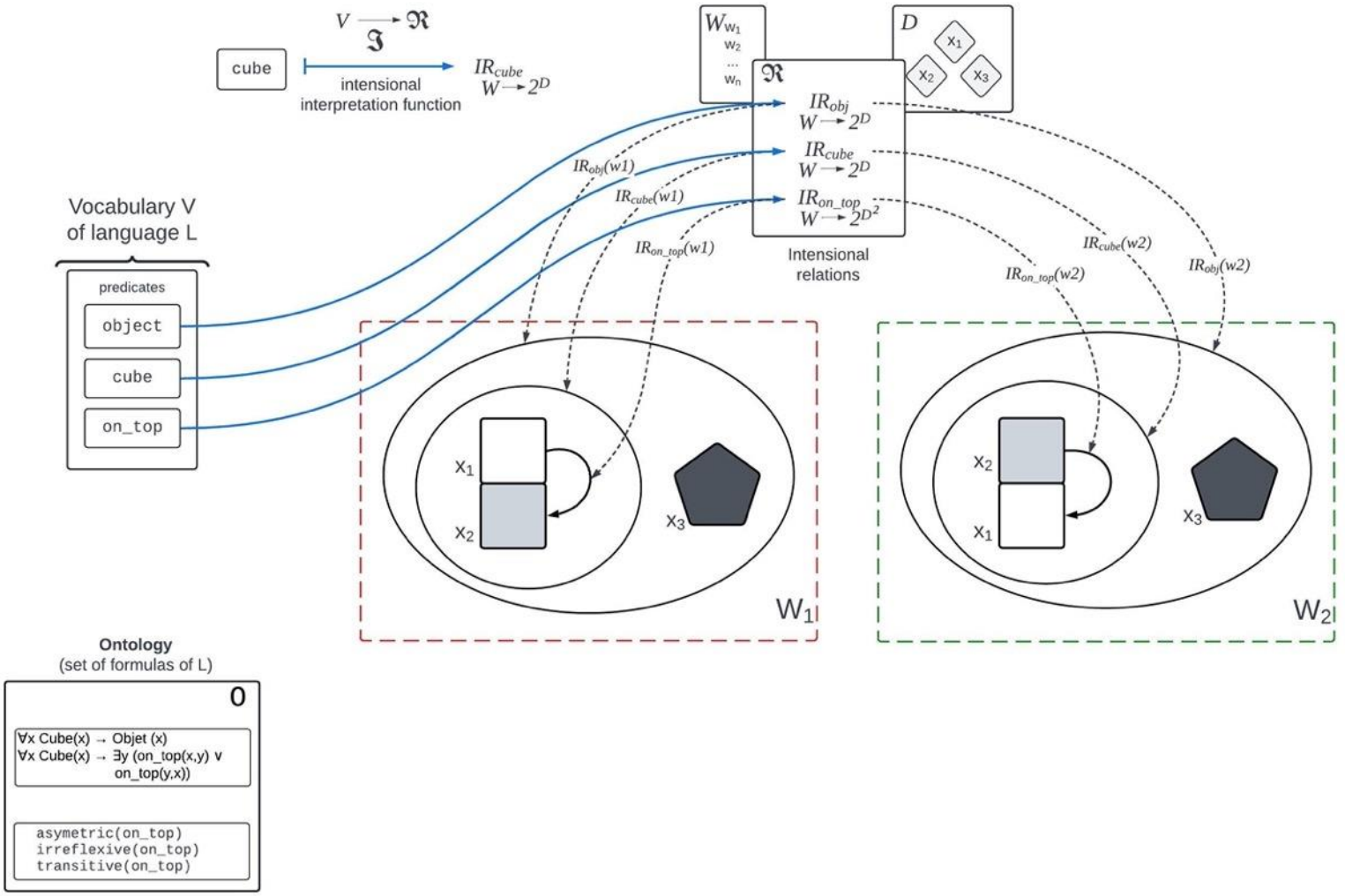

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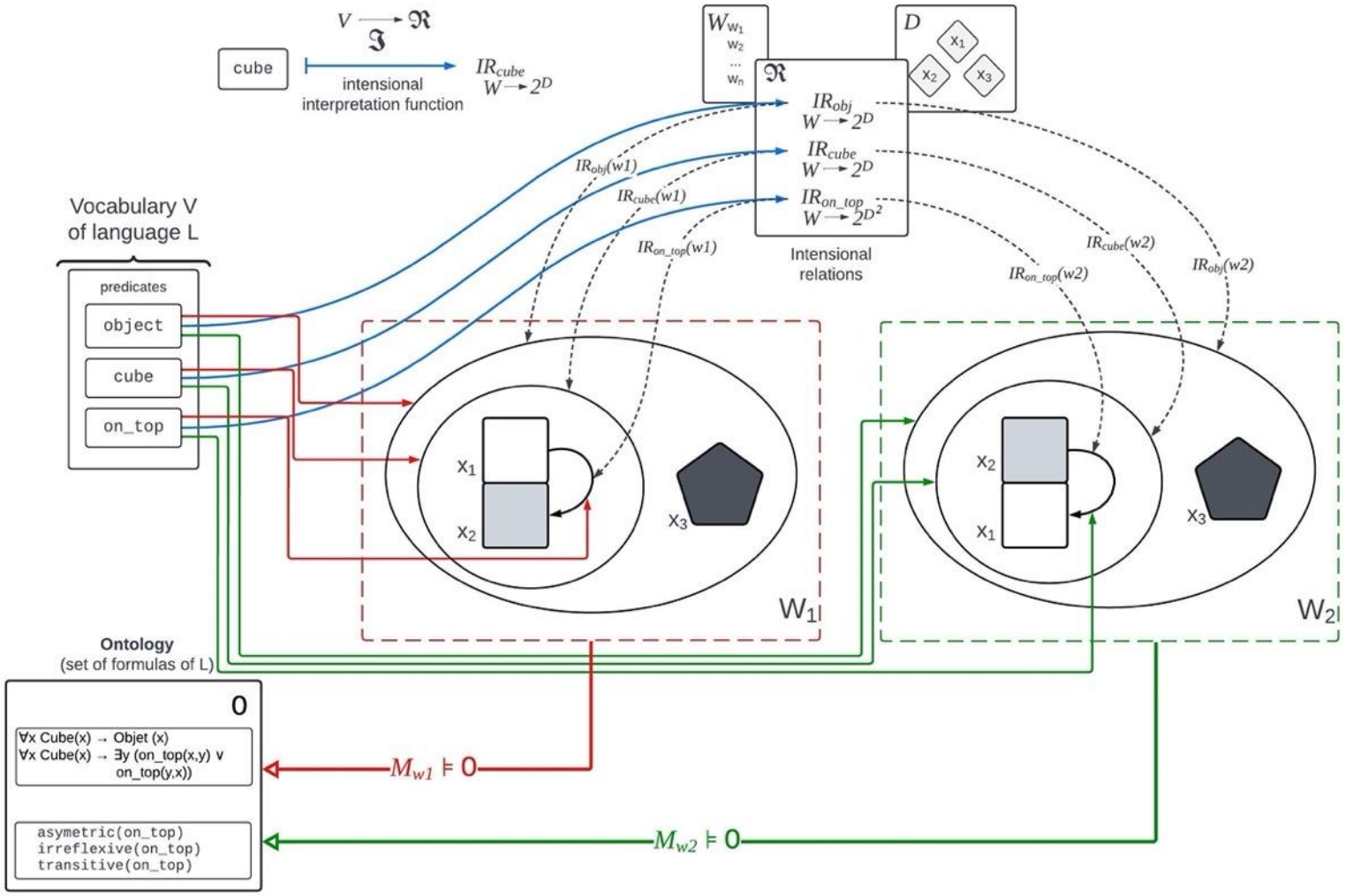
/ See: Neuhaus, F. On the Definition of 'Ontology,' *Proceedings of the Joint Ontology Workshops 2017 (JOWO 2017)*, CEUR Workshop Proceedings, 2018.

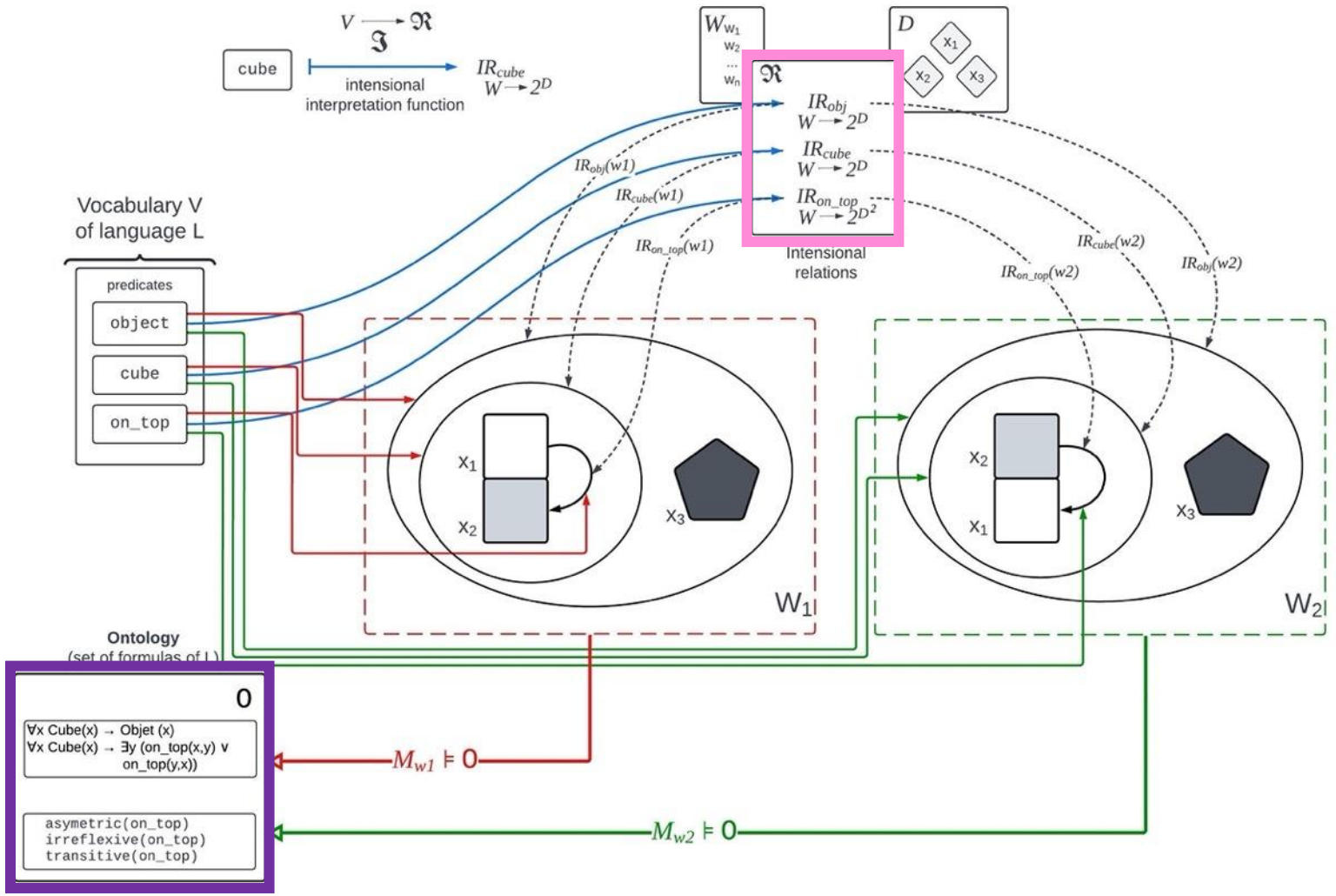


Ontology: logical theory designed so that the set of its models (in the sense of model theory) approximates as well as possible the set of intended models.

Intended meaning vs. meaning specification

Indeterminacy of *meaning*, rather than indeterminacy of reference

(Intended) meaning

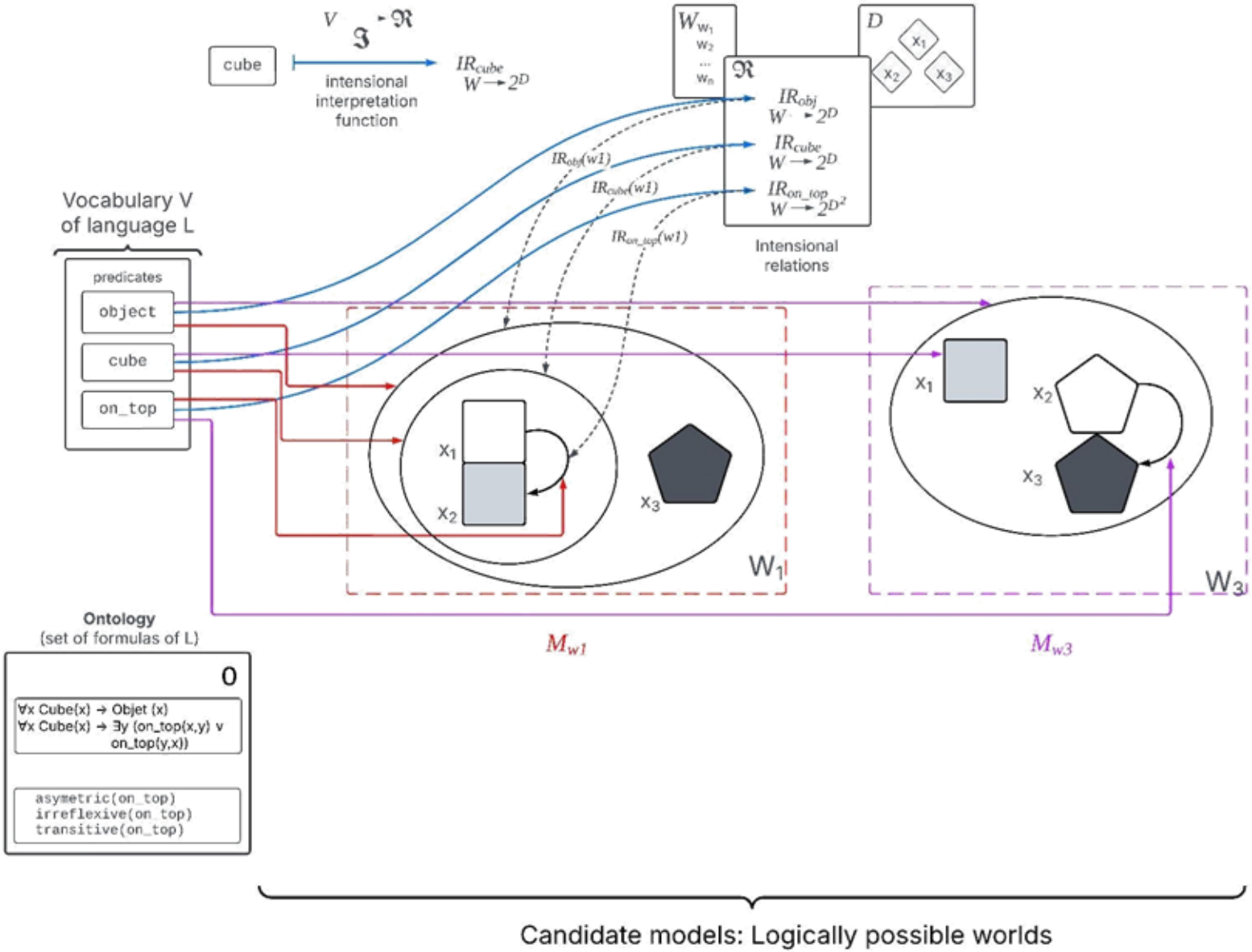


determines for each term its "meaning specification" (to be defined in part III)

Meaning specification **interconnections (holism?)** will influence the extent of **indeterminacy of intended meanings**.

Metaphysical question: Can we understand this in terms of possible worlds?

Barton, A., Fabry, P. & Ethier, J.-F. Charting Possible Worlds: The Quest for Meaning in Ontologies, *FOIS 2025*, accepted.



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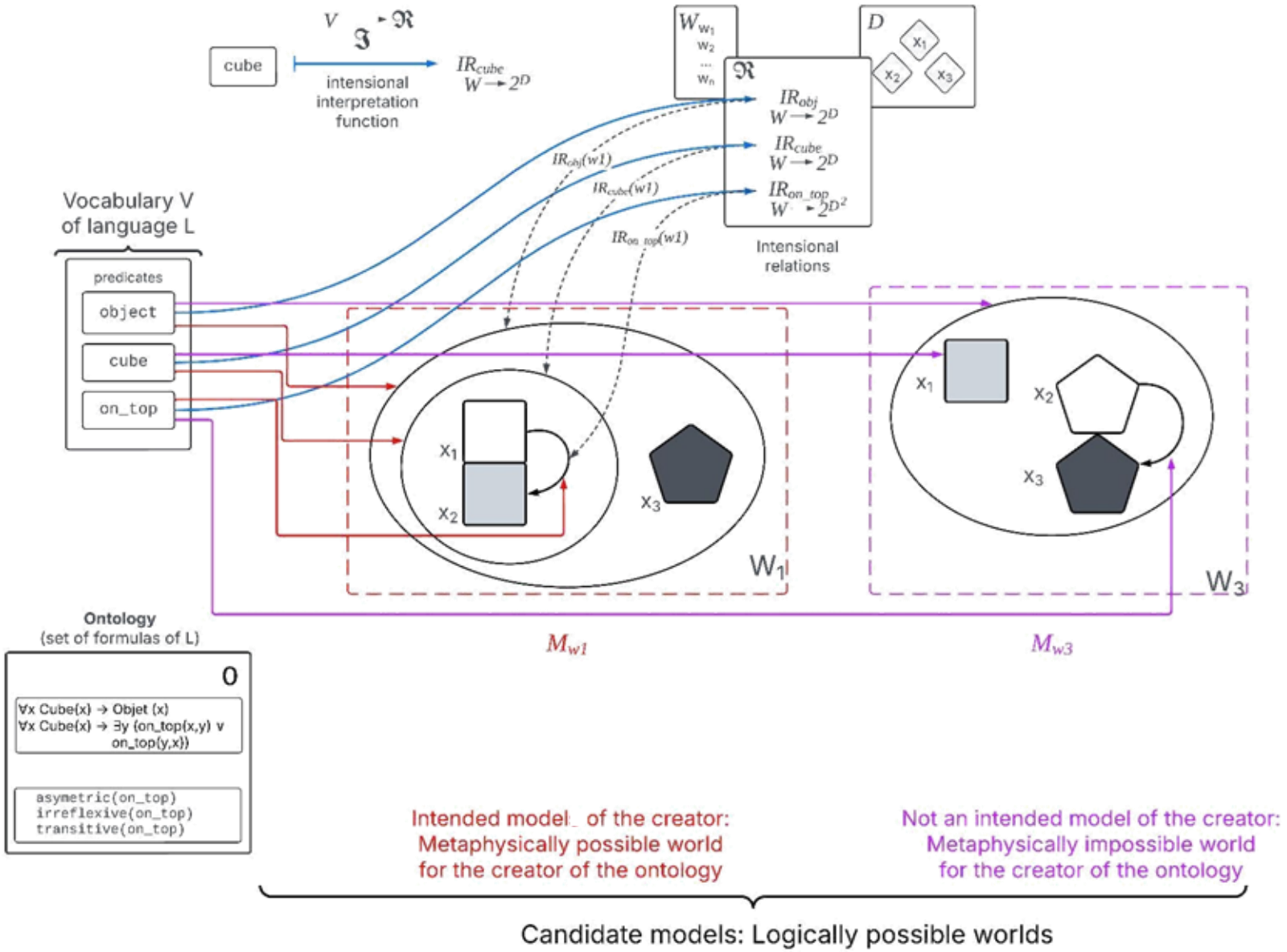

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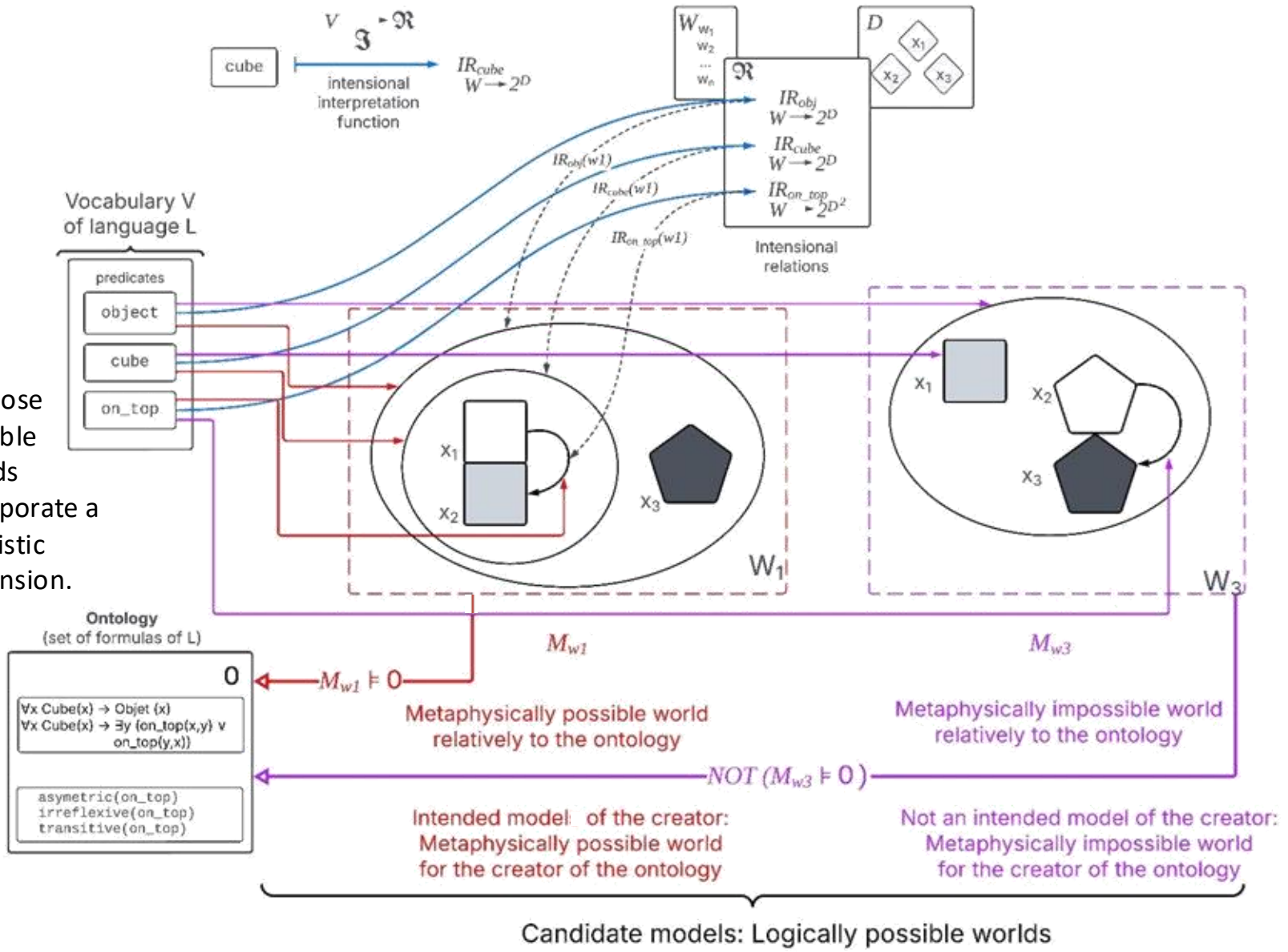
All those possible worlds incorporate a linguistic dimension.



Outline

Part I: **Introducing intended meaning and meaning specification**

Part II: **The analytic/synthetic distinction**

Part III: **The limits of meaning holism**

The Analytic/Synthetic Distinction

I. Kant, *Critique of Pure Reason*, 1781

- A **semantic** distinction that goes back to Kant:
  - An **analytic** statement is true or false in virtue of the meanings of its terms.
  - A **synthetic** statement is true or false not solely in virtue of the meanings of its terms.
- Different from the **epistemological** *a priori / a posteriori* distinction:
  - ***A priori*** statement: justifiable independently of experience
  - ***A posteriori*** statement: not justifiable independently of experience

"Bachelors are unmarried men."

"Bachelors are happy."

"2+2=4"

"the speed of light is 299,792,458 m/s"

	Analytic	Synthetic
A priori	✅	❓ I. Kant, *Critique of Pure Reason*, 1781
A posteriori	❓: "Water = H20" Reinterpretation of necessary a posteriori statements by S.A. Kripke, *Naming and Necessity*, Springer, 1980 → Barton, A., Fabry, P. & Ethier, J.-F. Charting Possible Worlds: The Quest for Meaning in Ontologies. *FOIS 2025.*	✅

Analytic vs. synthetic in ontologies

F. Neuhaus, J. Hastings (2022) Ontology development is consensus creation, not (merely) representation, Applied Ontology, 1–19.

R. Arp, B. Smith, A.D. Spear (2015) *Building Ontologies with Basic Formal Ontology*, The MIT Press

- Distinction largely absent from the applied ontology literature.
- Neuhaus & Hastings (2022) : “[t]he representation of empirical knowledge is a secondary task of an ontology, its primary task is to establish a vocabulary for a formal language, which may be used to express empirical knowledge.”
- / Arp, Smith & Spear (2015) : “Ontology is concerned with representing the results of science at the level of general theory (the generalizations and laws of science)”

Analytic vs. synthetic statements annotations

- OWL: we could introduce annotation properties in order to tag statements as analytic or synthetic.
- Consider the two following statements:
  - (AX_H) VH EquivalentTo (Vertebrate and has_part some Heart)
  - (AX_K) VH EquivalentTo (Vertebrate and has_part some Kidney)

Tag
Analytic
Synthetic

- Analytic statements effectively constrain the reference of a term.
- Synthetic statements:
  - express a regularity that is contingent upon how the world is.
  - can merely act as heuristic devices when making judgments of instantiation:

  One might take the risk to classify a particular vertebrate with a kidney as an instance of VH on the basis of (synthetic) AX_K, but one might be wrong.

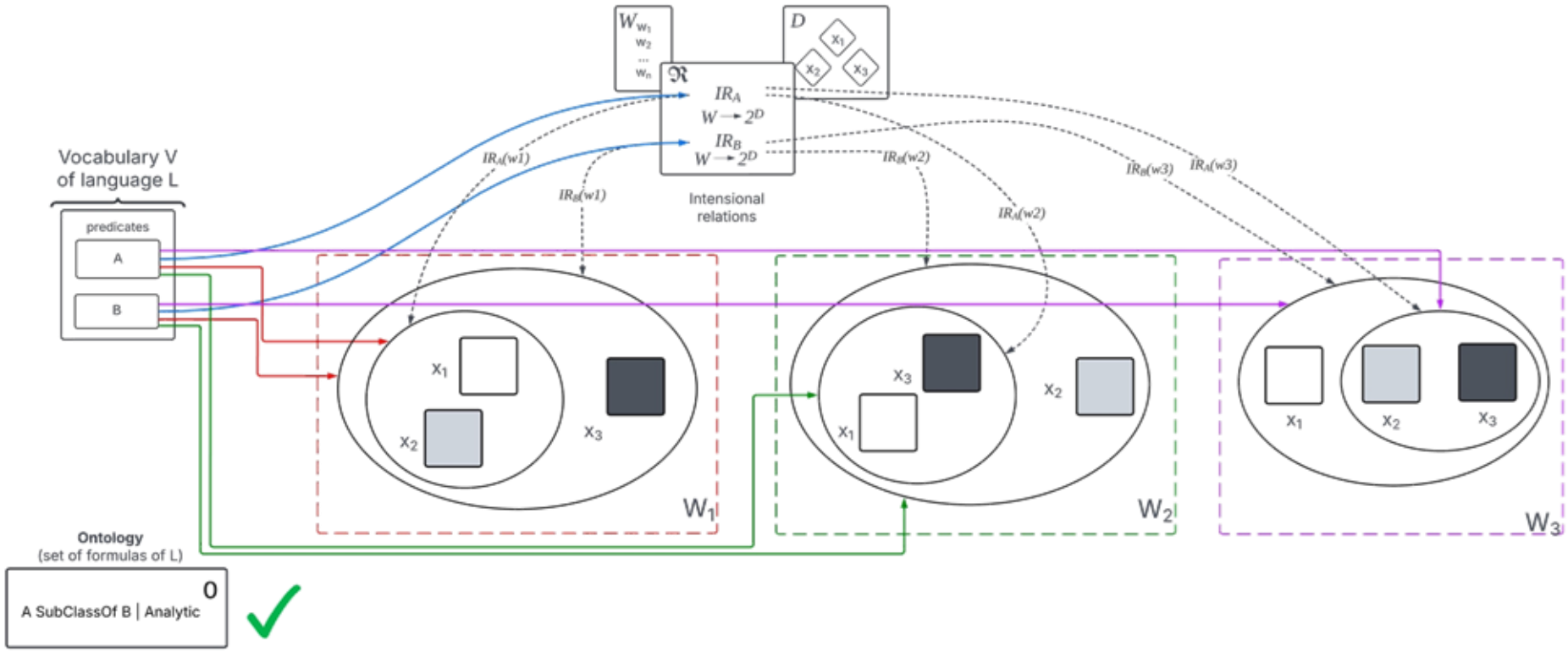
Additional distinction: Necessary vs. contingent statements

- The necessary/contingent distinction is a *metaphysical* distinction:
  - a statement is **necessarily true** if it holds in all possible worlds
    e.g., "2 + 2 = 4"
  - it is **contingently true** if it is true in our world but not in all possible worlds
    e.g., "Paris is the capital of France"

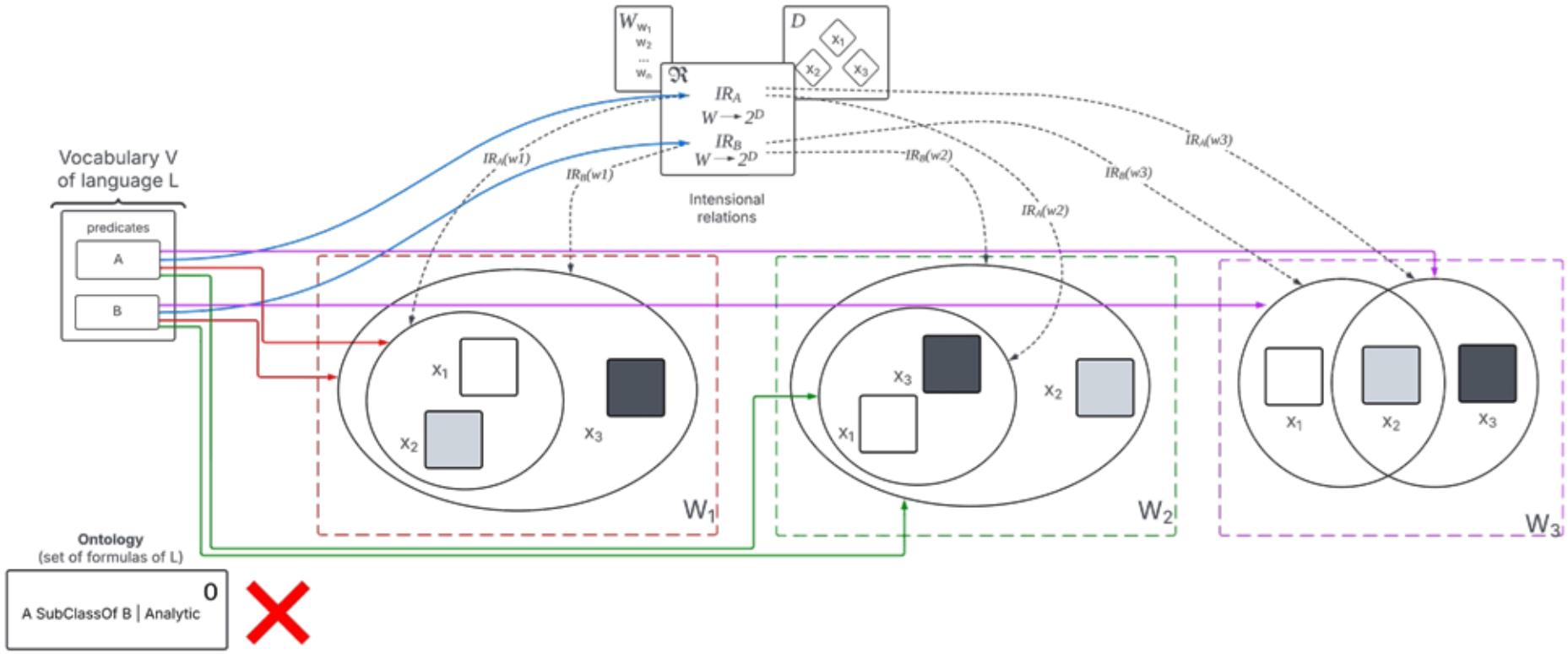
- Can we construe the analytic/synthetic distinction in terms of the necessary/contingent distinction?

- Example: what is claimed by 'A SubClassOf B' (with A and B named or anonymous classes) when it is declared as:
  - analytic?
  - synthetic?

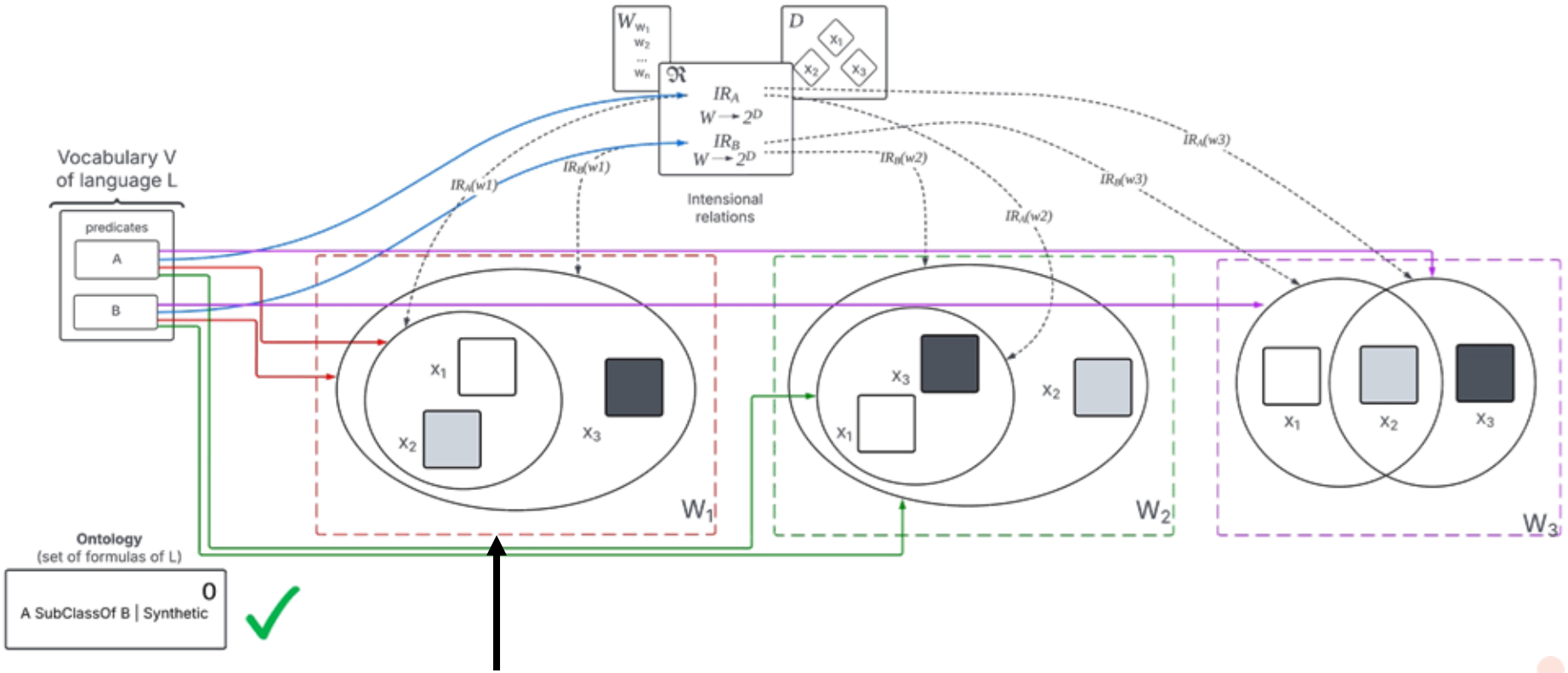
True ‘A SubClassOf B’ analytic statement



False ‘A SubClassOf B’ analytic statement



True ‘A SubClassOf B’ synthetic statement



Our world

SubClassOf analytic vs. synthetic OWL statement

Barton, A., Fabry, P. & Ethier, J.-F. Charting Possible Worlds: The Quest for Meaning in Ontologies, *FOIS 2025*, accepted.

- Analysis of the analytic/synthetic distinction in terms of the necessary/contingent distinction

- Extension of the Guarino et al. (2009) framework:
  - *SubClassOf analytic OWL statement:= An OWL statement of the form 'A SubClassOf B' claiming that,* ***for every world w ∈ W****,* $IR_A(w)$ *is included in* $IR_B(w)$*.*
  - *SubClassOf synthetic OWL statement:= An OWL statement of the form 'A SubClassOf B' claiming that,* ***at least for our world w=*** w_1 ***but not for every world w ∈ W****,* $IR_A(w)$ *is included in* $IR_B(w)$*.*

- Analytic and synthetic axioms should be distinguished in ontology engineering, as they convey different content, even if they have the same logical formulation.

Outline

Part I: **Introducing intended meaning and meaning specification**

Part II: **The analytic/synthetic distinction**

Part III: **The limits of meaning holism**

Defining Meaning Specification

Reminder of our two first questions:

Q1) How can we define meaning in applied ontologies?

Q2) What is the extent of meaning holism, compared to its characterization in (H)?

(H) “The determinants of the meanings of our terms are interconnected in a way that leads a change in the meaning of any single term to produce a change in the meanings of each of the rest.”

OWL example of (formal) meaning specification of an ontological class term

Barton, A., Fabry, P., Ethier, J.-F. (2024) Meaning Holism and Indeterminacy of Reference in Ontologies . Formal Ontology in Information Systems. Proceedings of the 14th International Conference (FOIS 2024). IOS Press.

Meaning specification of VH

Analytic theory of the ontology

Mammal SubClassOf Vertebrate
Vertebrate SubClassOf Animal
VH EquivalentTo (Vertebrate and has_part some Heart)

Deductive closure of the analytic theory (trivial consequences omitted)

VH SubClassOf (Animal and has_part some Heart)
(Mammal and has_part some Heart) SubClassOf VH

Synthetic theory of the ontology

VH EquivalentTo (Vertebrate and has_part some Kidney)

Meaning specification of an ontological class term

- (MEAN)^{OWL} The formal meaning specification of a class term A in an OWL ontology O is the collection of non-partly tautological statements of the form:
  - A SubClassOf Expr
  - A EquivalentTo Expr

  in the deductive closure of O's analytic theory.

- (MEAN) The formal meaning specification of a class term in an ontology O is the collection of non-partly tautological formal statements expressing necessary (including necessary and sufficient) conditions on this term **in the deductive closure of O's analytic theory**.

- Example of "partly tautological" statements (credit Fabian Neuhaus):
  - A SubClassOf (C or not-C)
  - A SubClassOf (B and (C or not-C))

- Answer to question Q1): How can we define meaning in applied ontologies?

Two limits on meaning specification (MS) holism

- O_1 at t1: AX1, AX2
- O_1 at t2: AX1, AX2, AX3

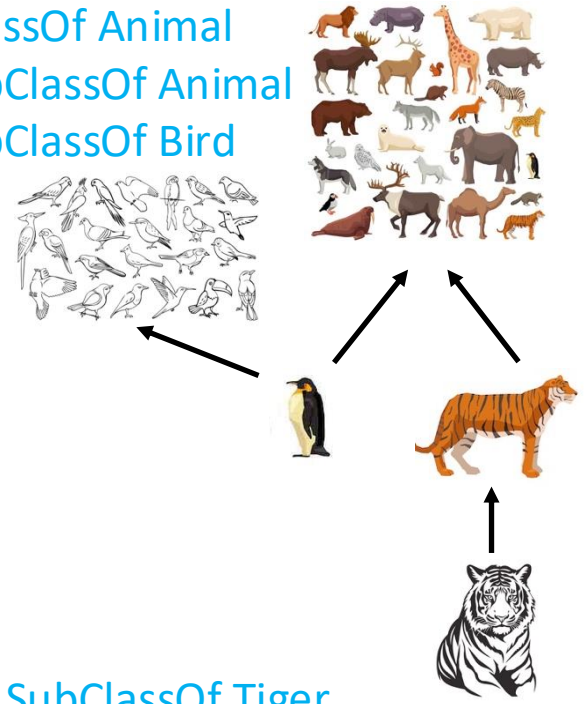
The MS of Penguin has changed

/ the MS of Tiger has not changed

→ **First limit on meaning holism:**

One can add conditions changing the MS of a term without changing the MS of another term.

(AX1) Tiger SubClassOf Animal
(AX2) Penguin SubClassOf Animal
(AX3) Penguin SubClassOf Bird



O_1 at t3: AX1, AX2, AX3, AX4

The MS of Tiger has **not** changed

→ **Second limit on meaning holism:**

One can add sufficient conditions on a term without changing the MS of this term.

(AX4) White_tiger SubClassOf Tiger

Partial answer to question Q2) What is the extent of meaning holism, compared to its characterization in (H)?

Meaning specification dependency

A SubClassOf Expr
A EquivalentTo Expr

mentions B, C, D…

→ The meaning specification of A **depends on** the meaning specification of B, C, D…

VH EquivalentTo (Vertebrate and has_part some Heart)
VH SubClassOf (Animal and has_part some Heart)

The meaning specification of VH **depends on** the meaning specification of Vertebrate, Animal and Heart.

Syntactic characterisation
/ Neuhaus et al. propose several relations of semantic dependencies

Neuhaus, F., Glauer, M., Mossakowski, T., Gerlach, L. & Heidfeld, C. Semantic Dependency in Ontologies, FOIS 2025, accepted

Summary

- In a framework adapted from Guarino et al. (2009), because of the interconnections between meaning specifications, intended meanings are partly indeterminate.
- To define the meaning specification of a class term, we need to tag axioms as analytic or synthetic.
- This analytic/synthetic distinction can be identified with the necessary/contingent distinction in a possible worlds metaphysical framework.
- Endorsing this conception of meaning specification, holism is not as strong as sometimes assumed.

Going beyond

- Still a change of the MS of a term B might change the MS of the terms whose meanings depend on B. This phenomenon is not enough controlled in current ontology engineering.
- One must not alter the MS of class terms:
  - that one did not author;
  - or that one did author but that have already been made public and thus might have been reused by someone else.
- In such cases, alternative strategies should be used, e.g.:
  - suggesting changes to the author of the term;
  - introducing a new term.
- Current work focuses on developing a rigorously structured system to control this aspect of holism

Fabry, P., Barton, A. & Ethier, J.-F. Rethinking meaning and ontologies from the perspective of ontological units. Submitted.

Thank you for your attention!

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SCOR Online Seminar

Swiss Center for Ontological Research

June 10, 2025