Ontology-Driven Conceptual Modeling

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Brazil

IAOA Summer School
Trento, Italy, 2012
Day 1

ONTOLOGICAL FOUNDATIONS FOR STRUCTURAL CONCEPTUAL MODELS

GIANCARLO GUIZZARDI

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About

Created in 2006, NEMO (Núcleo de Estudos em Modelagem Conceitual e Ontologias) is a research group devoted to investigating the application of domain and foundational ontologies as well as ontology-based techniques in various aspects of conceptual modeling such as information modeling, enterprise modeling, agent-based systems and semantic web. We have been establishing a productive partnership with industry regarding the application of ontologies in sectors such as domain engineering, software engineering and Energy (Petroleum and Gas). Moreover, in the past three years, NEMO members have been actively participating in the consolidation of the Brazilian Ontology Community by carrying out activities such as the organization of some the first scientific events devoted to ontologies in Brazil.

NEMO has integrated the former LABES (Software Engineering Research Laboratory). LABES was funded in 1999 with the prominent purpose of investigating the application of ontology-based techniques in Software Engineering. In this area, one the key projects conducted inside this laboratory was the ODE (Ontology-Based Development Environment Project). This project investigated the use of domain ontologies for domain engineering and for the systematic development of semantically-aware object-oriented frameworks. This project resulted in a number of formal ontologies for several software engineering sub-domains (e.g., software requirements, software process, software quality, risk analysis, etc.). Once produced, these domain ontologies have been employed for the production of reusable frameworks for each of these domains. Finally, these frameworks were used for the production of a process-centered semantic software engineering integrated environment. Since 2003, the laboratory has also been involved in the development of projects in the use of ontologies (both as a reference framework as a knowledge representation artifact) for providing intelligent support in software engineering knowledge management. Since 2006, the LABES has been integrated to the recently created NEMO (Ontology and Conceptual Modeling Research Group).

Senior members:
Dr. Giancarlo Guizzardi (Foundational Ontologies, Conceptual Modeling)
Dr. João Paulo Andrade Almeida (Architectural Design, Enterprise Architecture, Enterprise Modeling, Business Process Modeling)
Dr. Renata Silva Souza Guizzardi (Multi-Agent Systems, Constructivist Knowledge Management, Goal-Based Modeling)
Dr. Ricardo de Almeida Falbo (Ontologies in Software Engineering, Ontological Engineering, Software Process and Quality)

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Concluído

What is Conceptual Modeling?

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"the activity of formally describing some aspects of the physical and social world around us for purposes of understanding and communication…Conceptual modelling supports structuring and inferential facilities that are psychologically grounded. After all, the descriptions that arise from conceptual modelling activities are intended to be used by humans, not machines... The adequacy of a conceptual modelling notation rests on its contribution to the construction of models of reality that promote a common understanding of that reality among their human users."

John Mylopoulos

Young and Kent (1958)

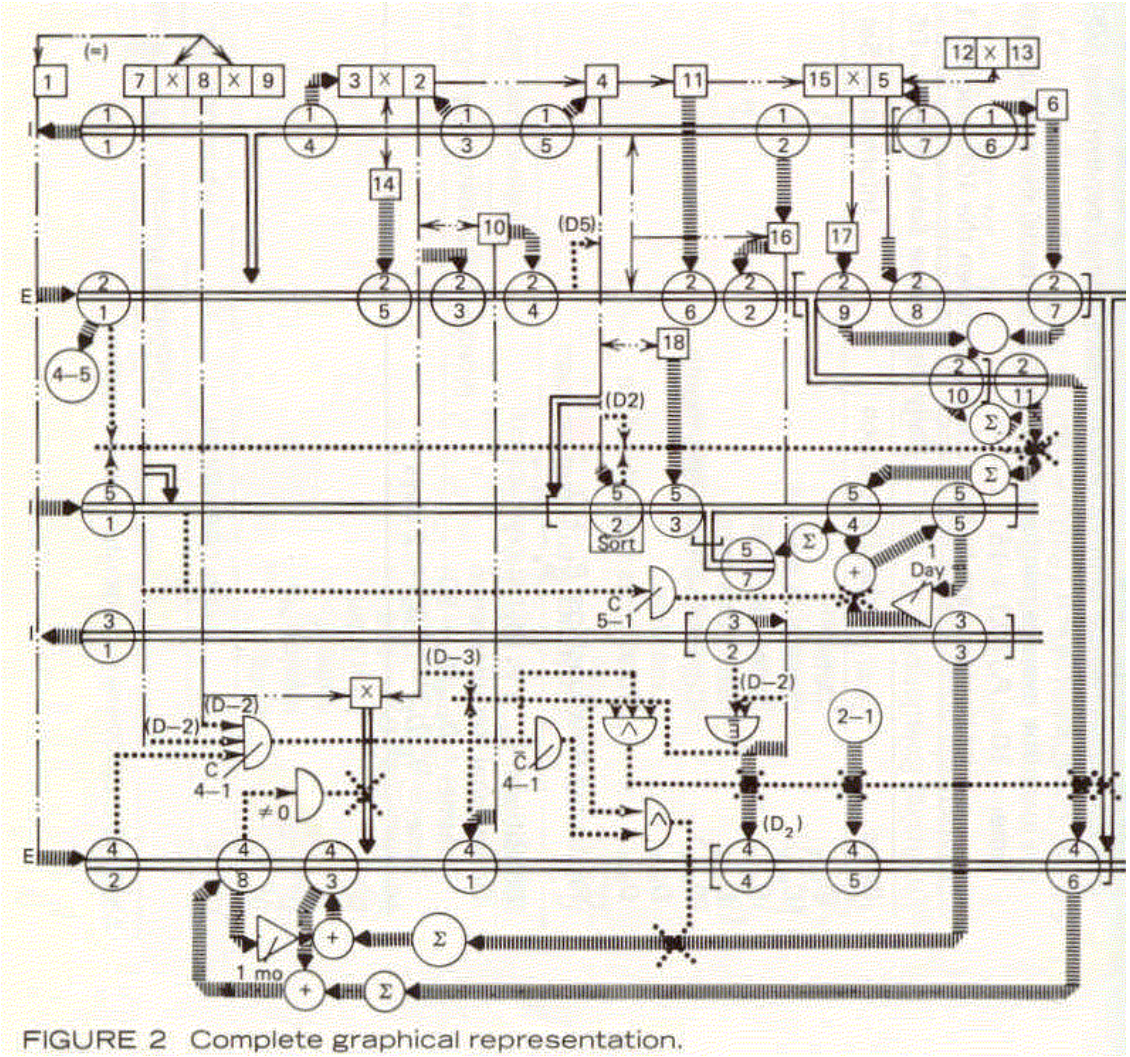

FIGURE 2 Complete graphical representation.

- **Information set/item**
- **Defining relationship**
- **Producing relationship**
- **Conditions**
- **Temporal aspects**

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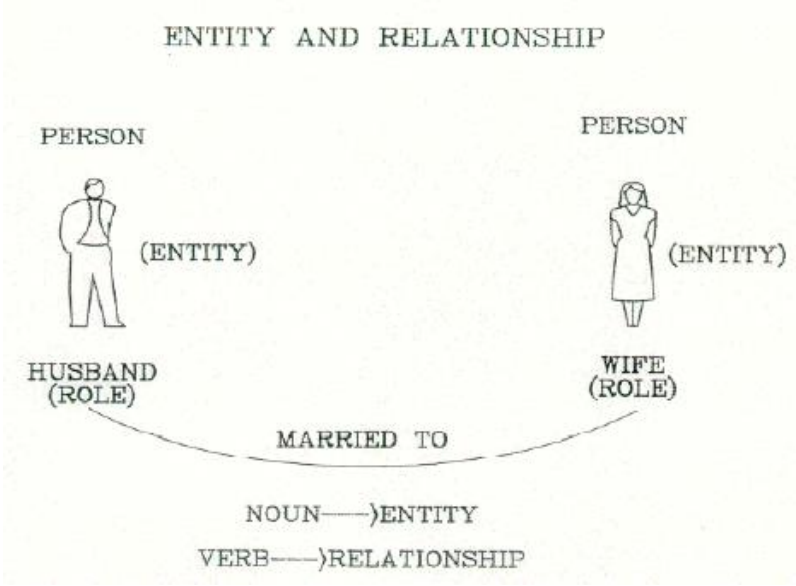
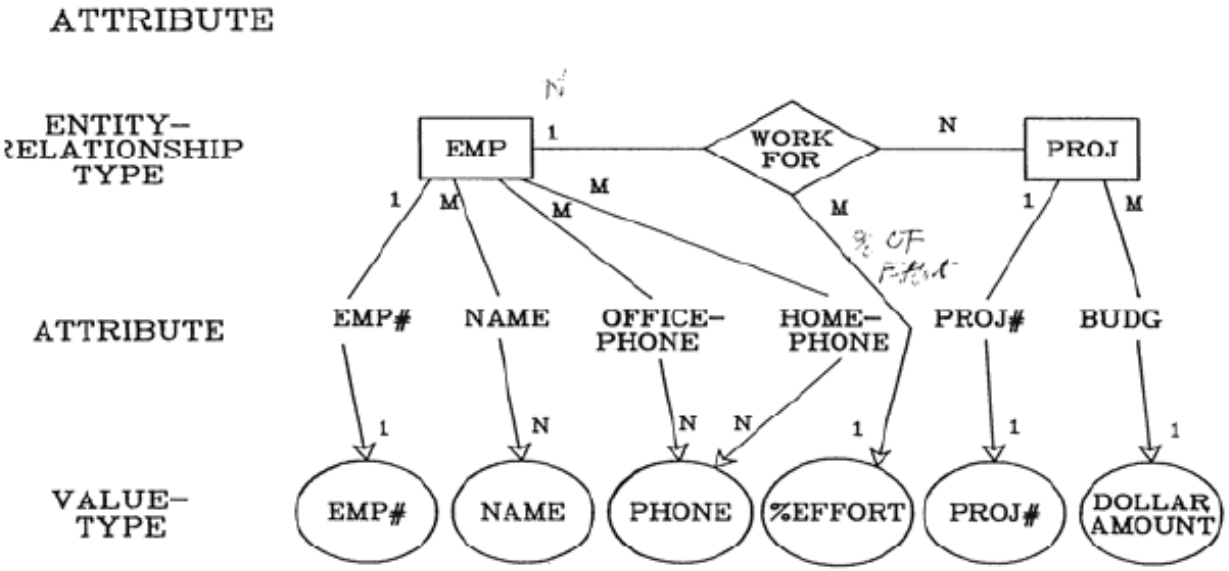
Why the need for an abstract formalism?

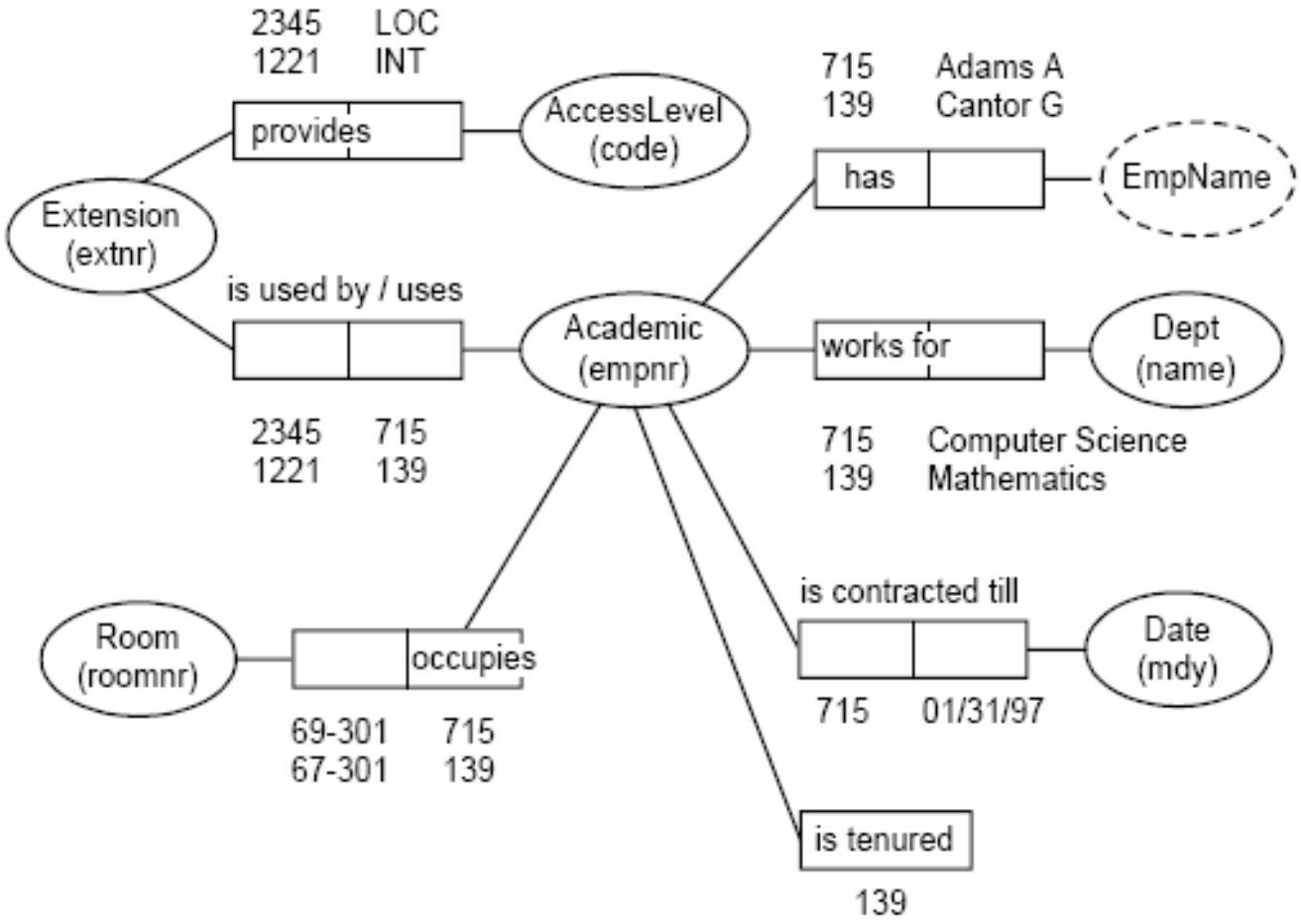
”Since we may be called upon to evaluate different computers or to find alternative ways of organizing current systems it is necessary to have some means of precisely stating a data processing problem independentaly of mechanization.”

E-R Diagrams (1976)





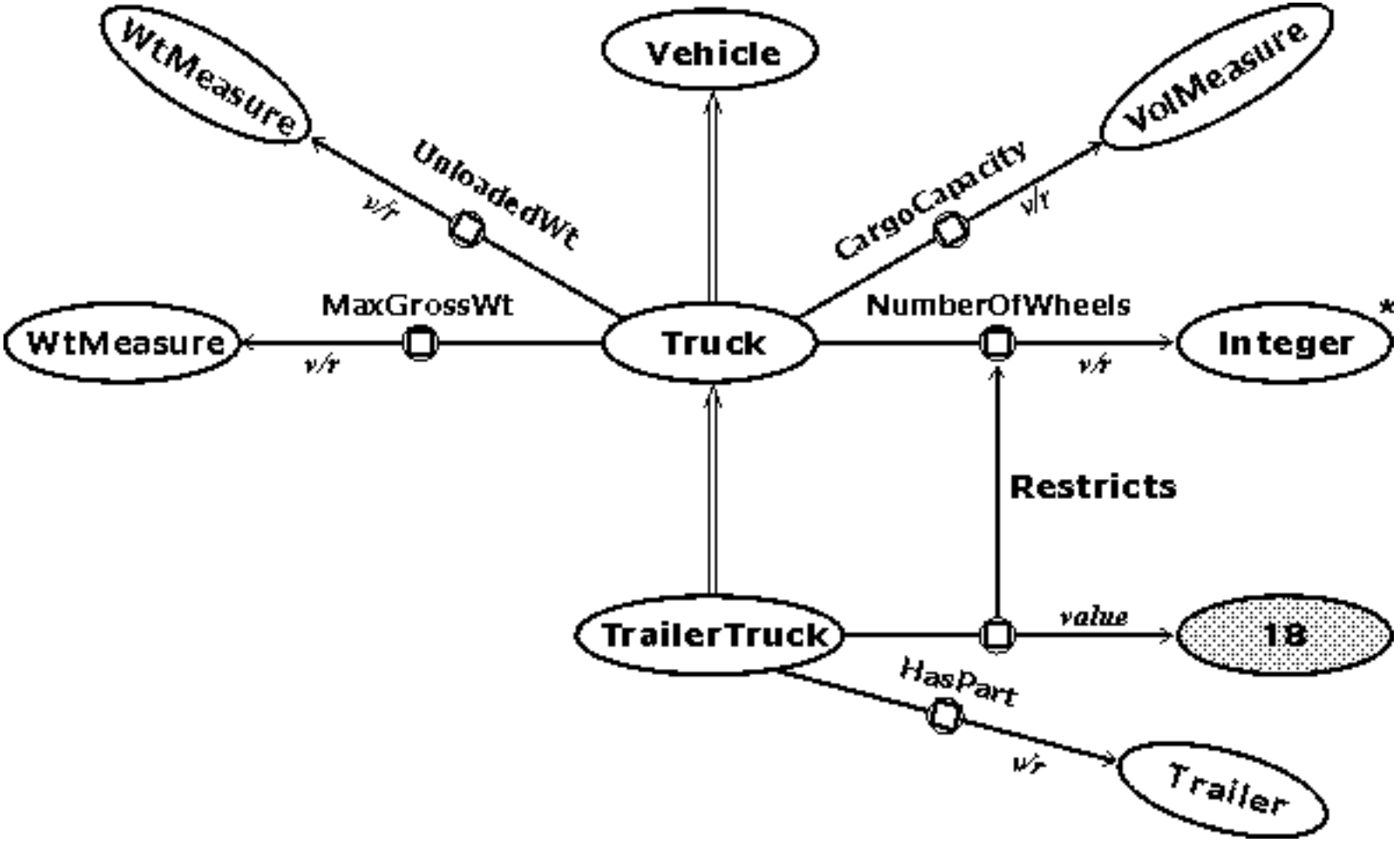
A sample NIAM schema (Faulkenberg and Nijssen)

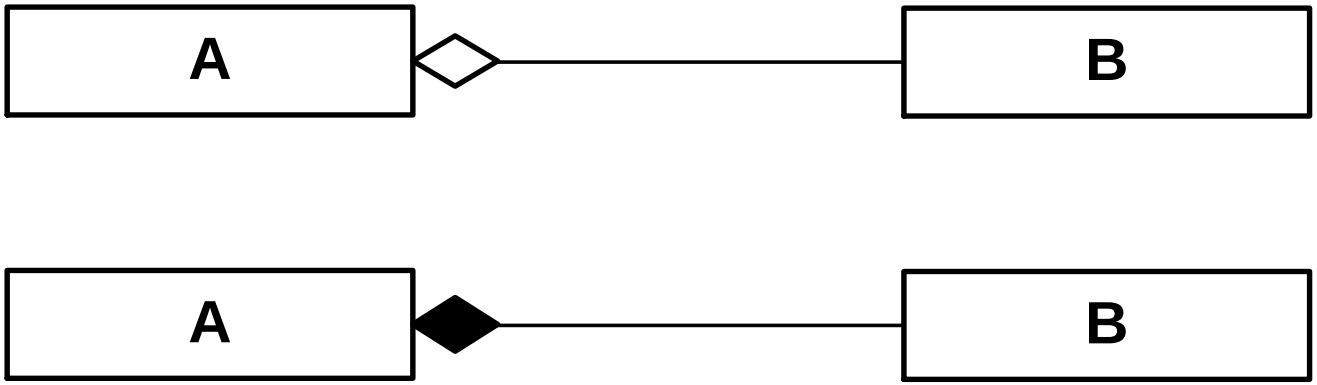


Common Trends

- *Natural Language* and *Cognition* do play an important role
- The idea of an *abstraction* mechanism to focus on aspects of the domain (as opposed to aspects of implementation)
- There is an implicit ontology in all these cases

KL-ONE (Brachman, 1979)




A
B
A
B

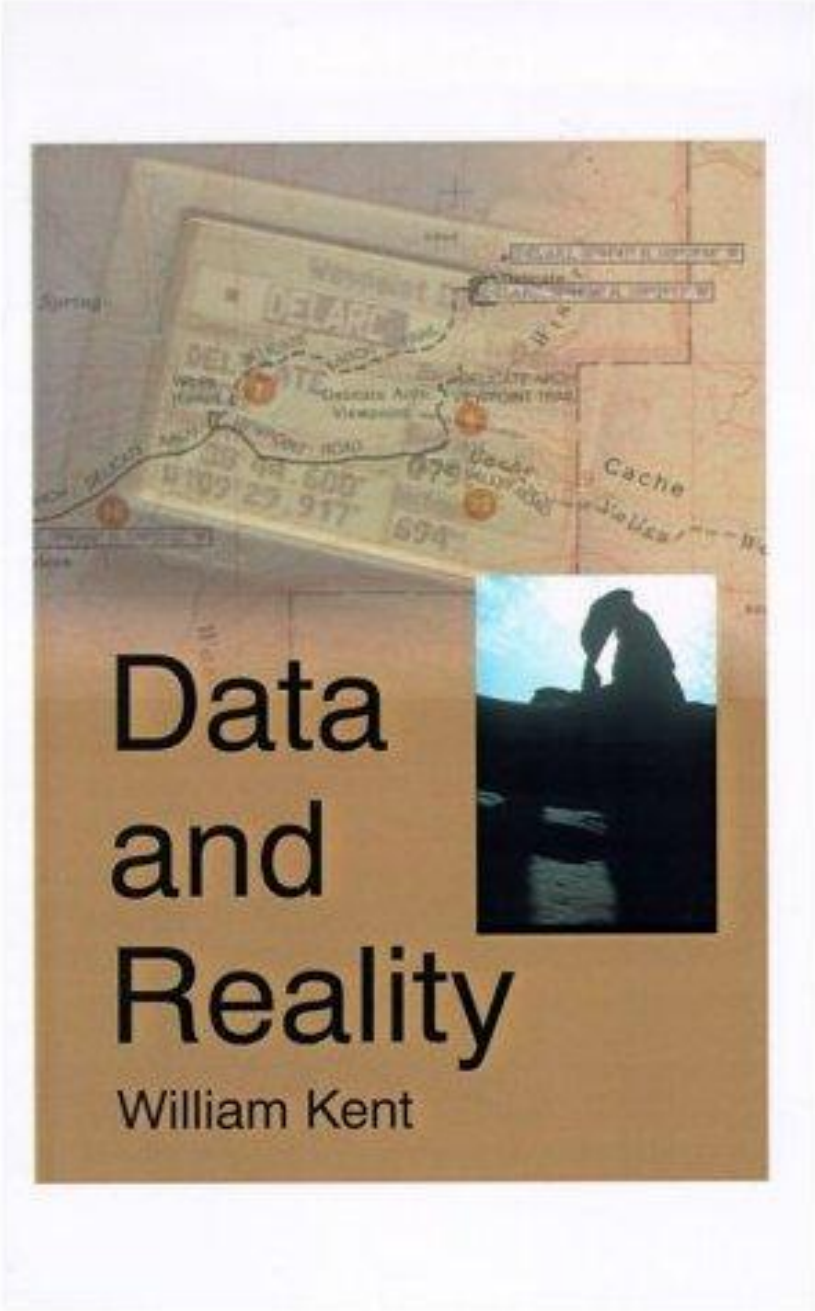
The opposite to Ontology is not Non-Ontology is Bad Ontology!

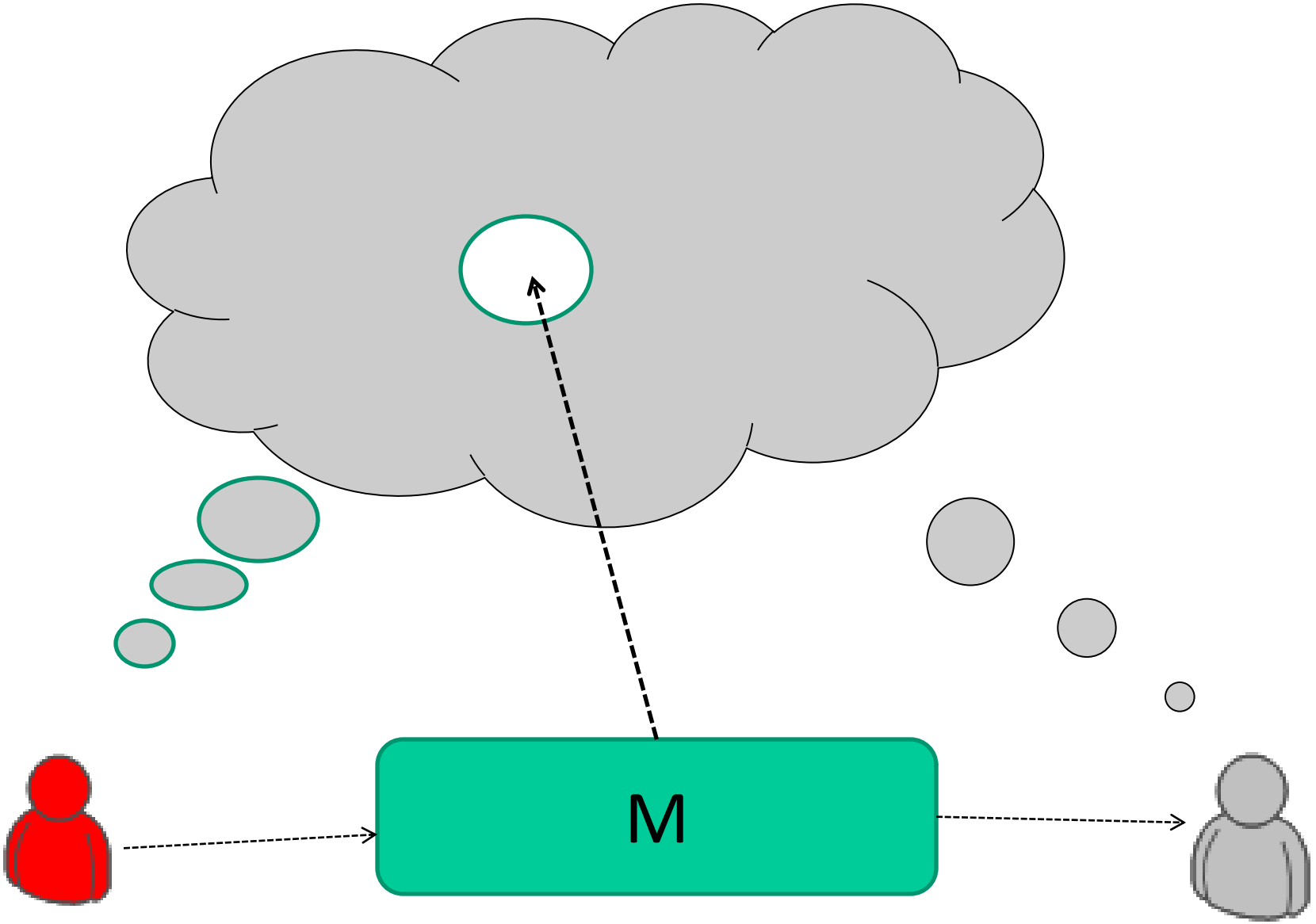
Ontologies in Information Sciences

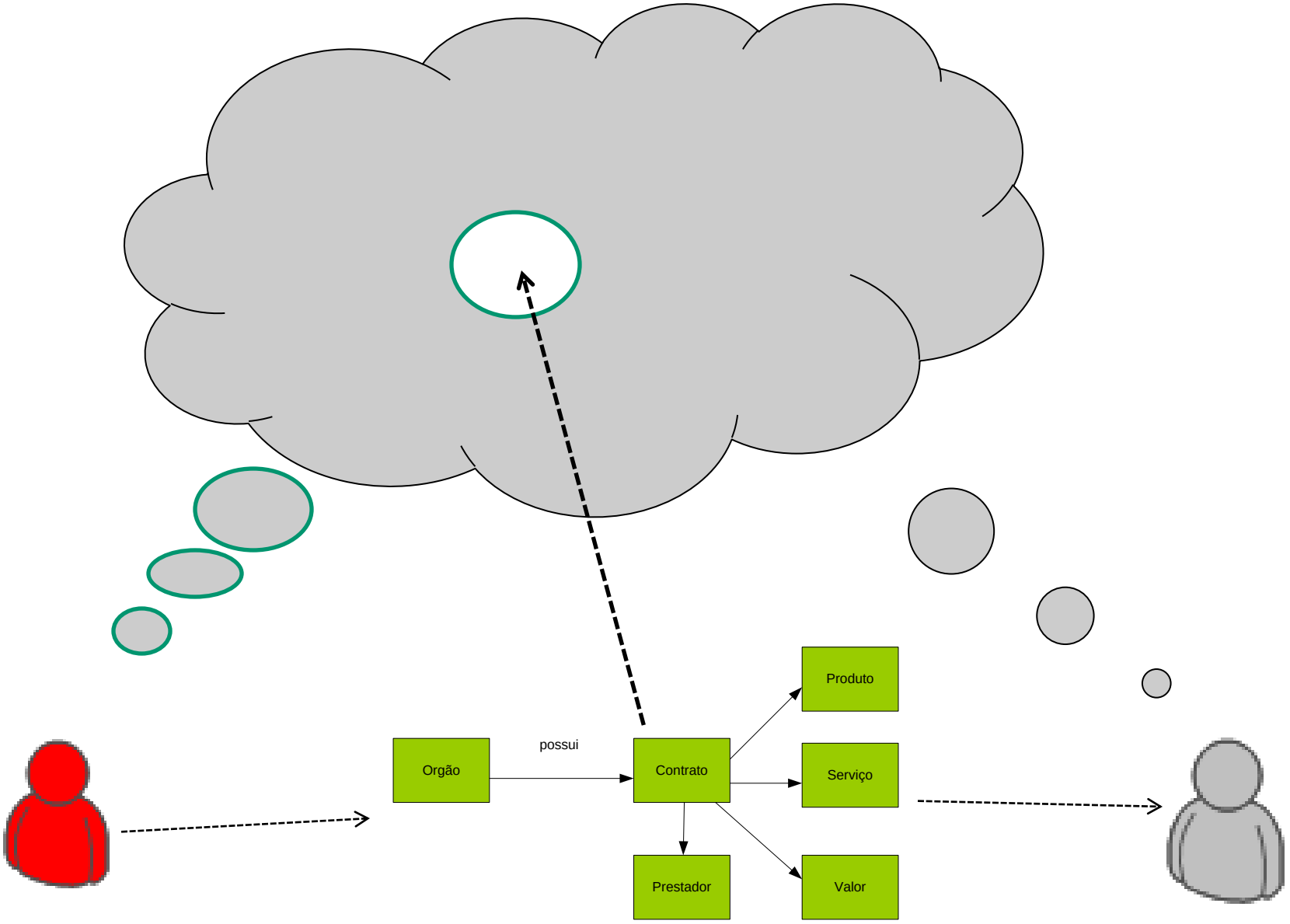
Foundations of data modeling by S. H. Mealy (1967): three distinct realms in the field of data processing, namely: (i) *"the real world itself"*; (ii) *"ideas about it existing in the minds of men"*; (iii) *"symbols on paper or some other storage medium"*.

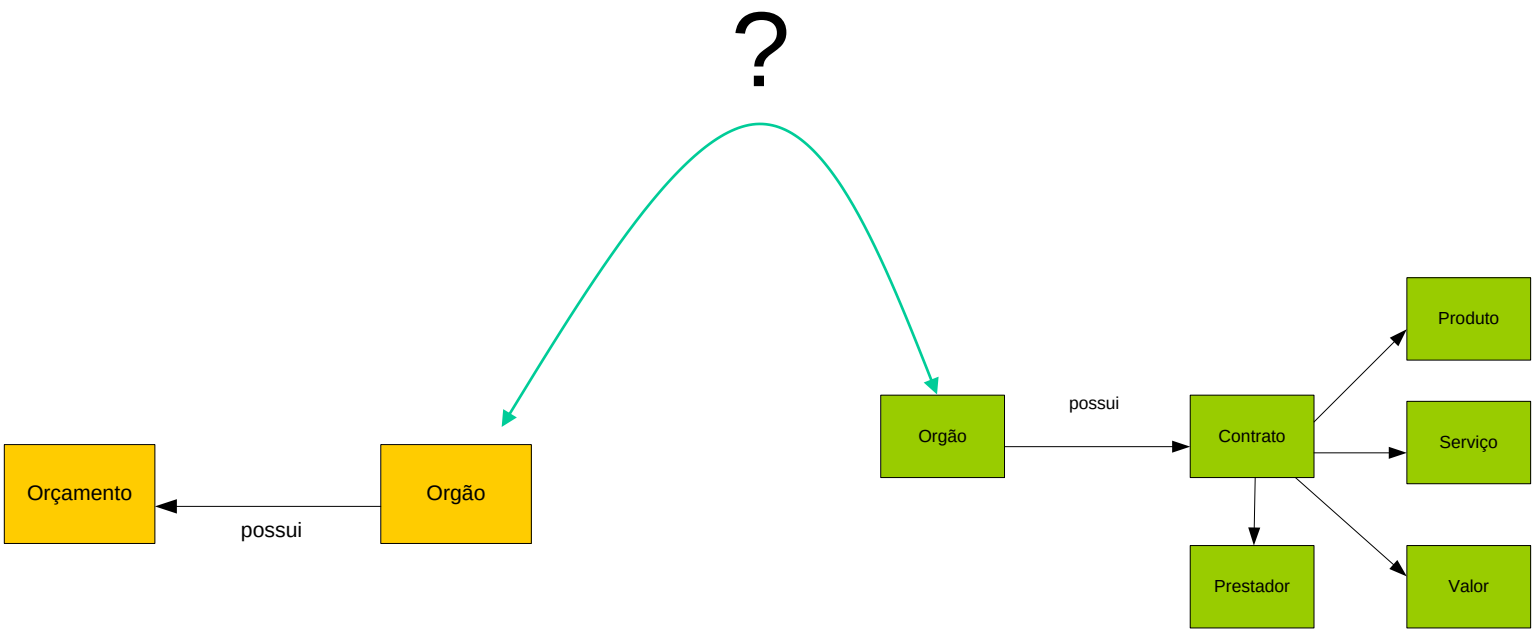
Kent's Data and Reality (1978)

BWW approach (1987)


Data
and
Reality
William Kent


M


Orgão
possui
Contrato
Produto
Serviço
Prestador
Valor


?
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Orgão
Orgão
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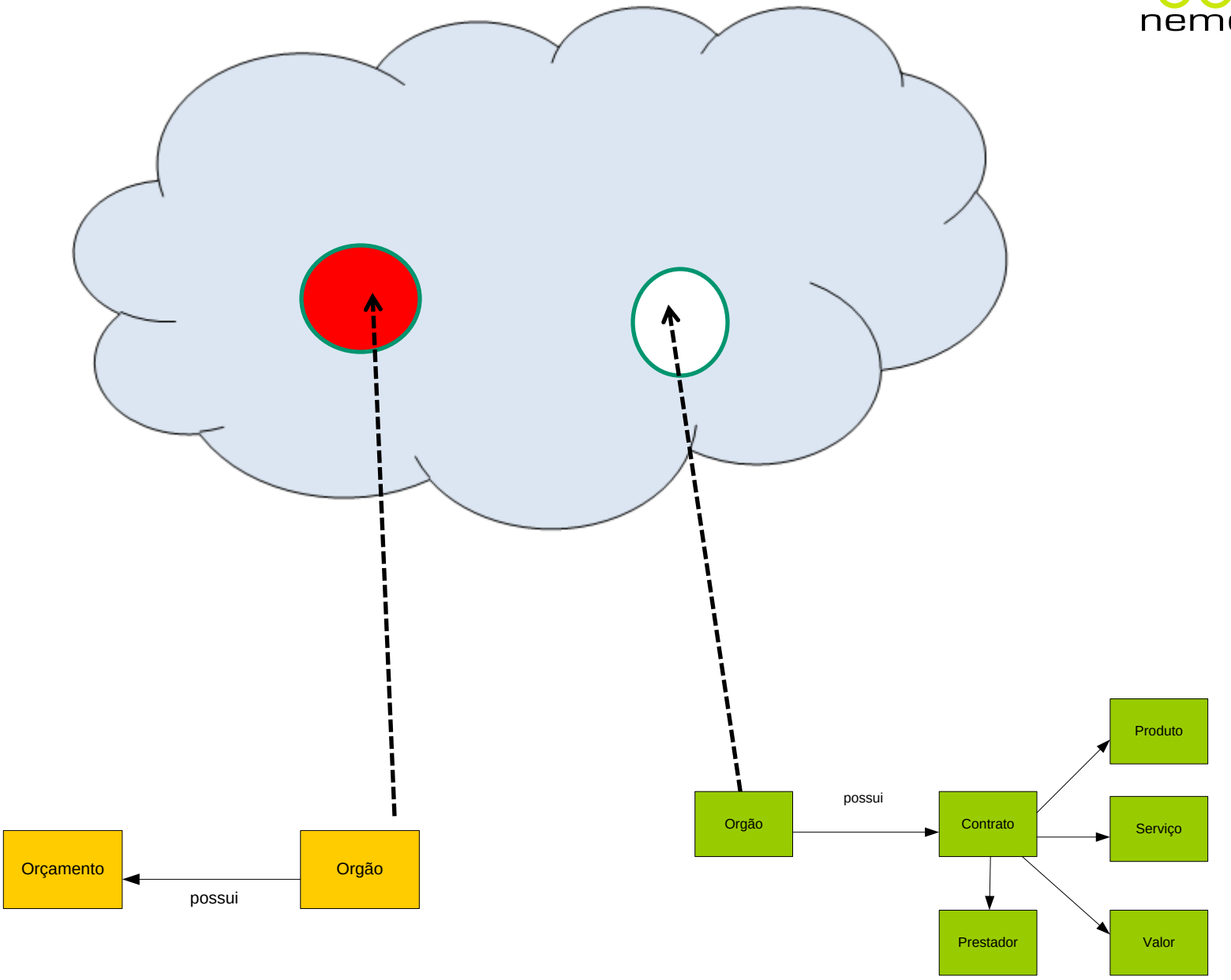
Contrato
Produto
Serviço
Prestador
Valor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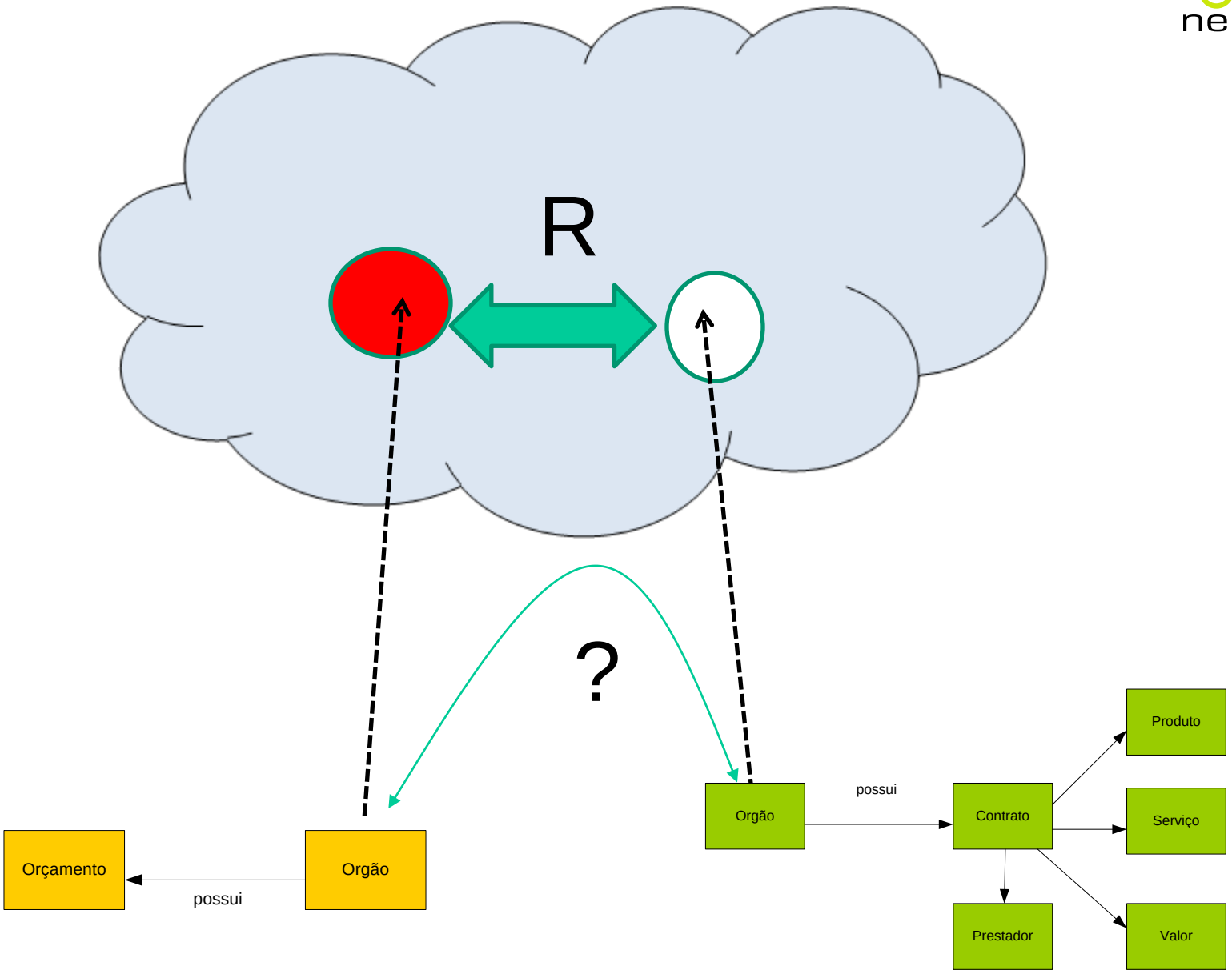
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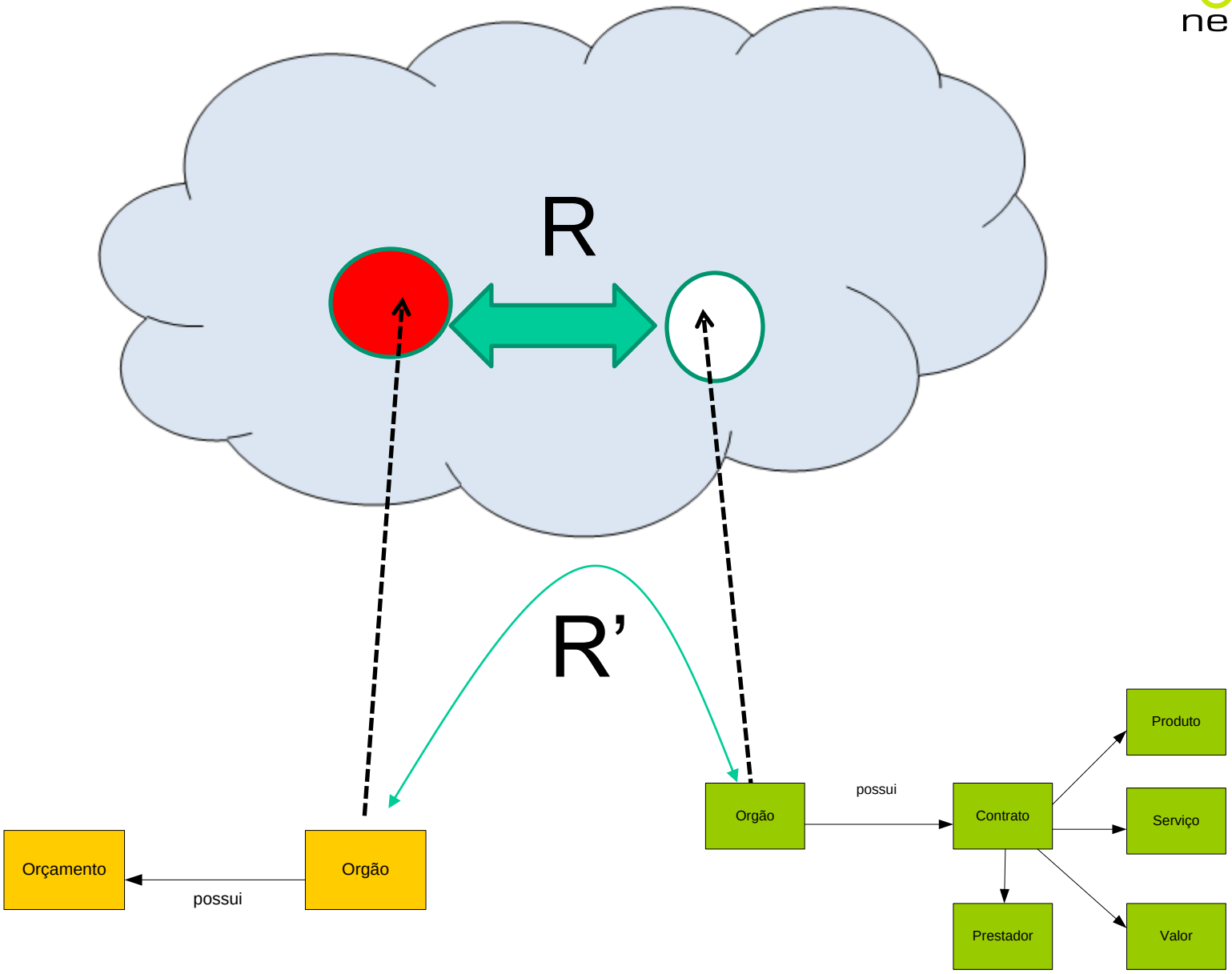
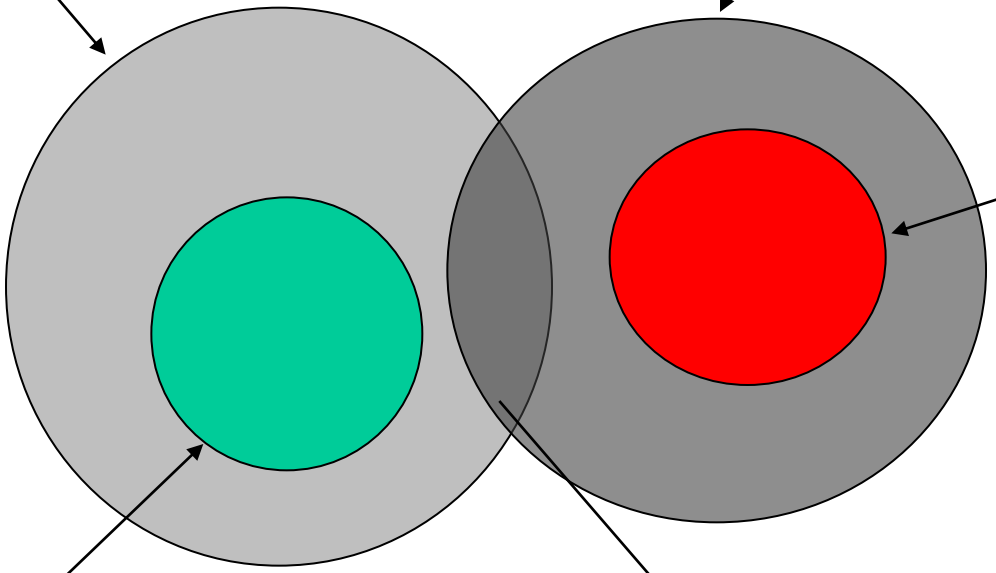

R
R’
Orçamento
possui
Orgão
Orgão
possui
Contrato
Produto
Serviço
Prestador
Valor

State of affairs represented by the valid models of Ontology O_1

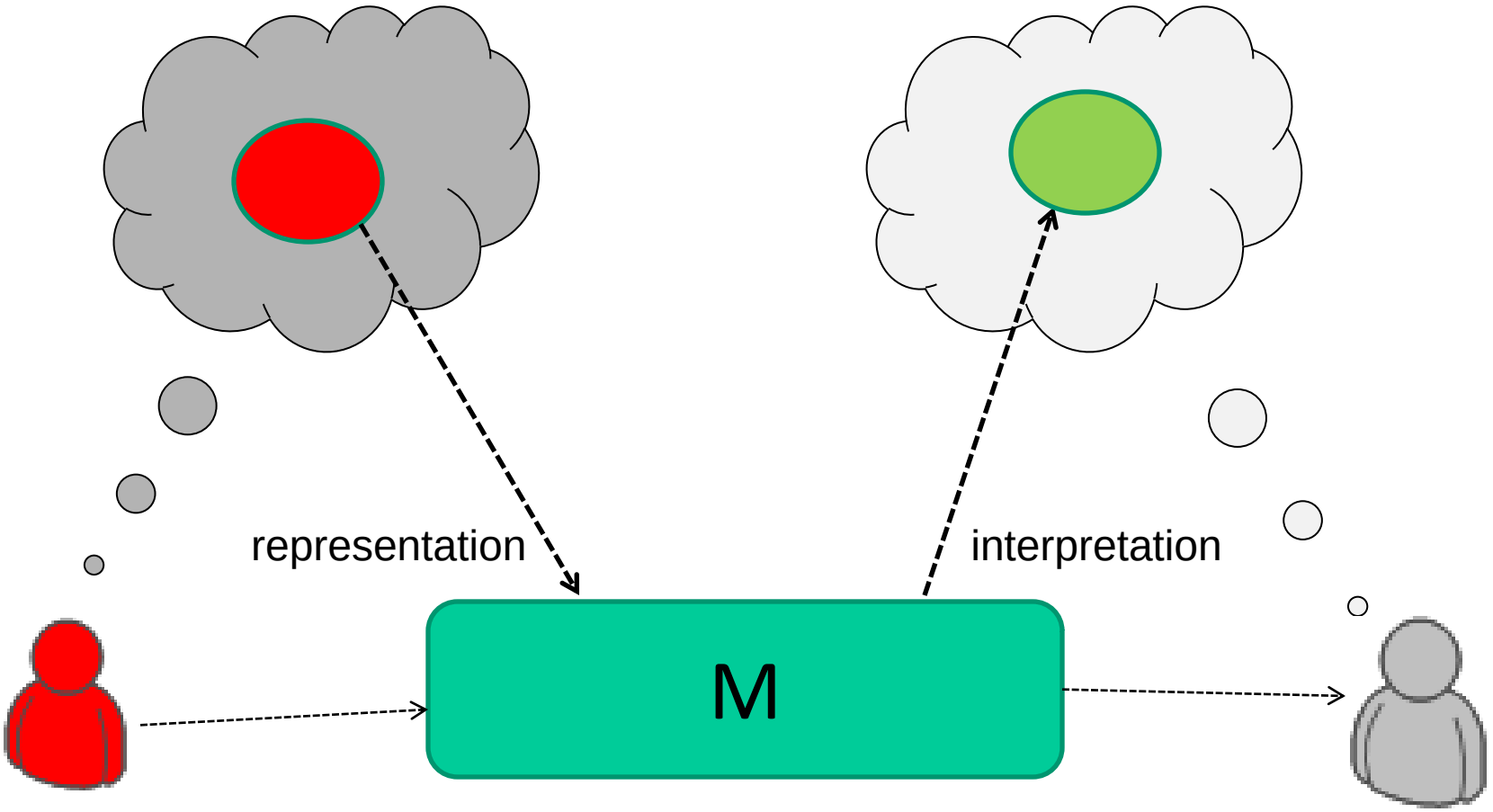
State of affairs represented by the valid models of Ontology O_2

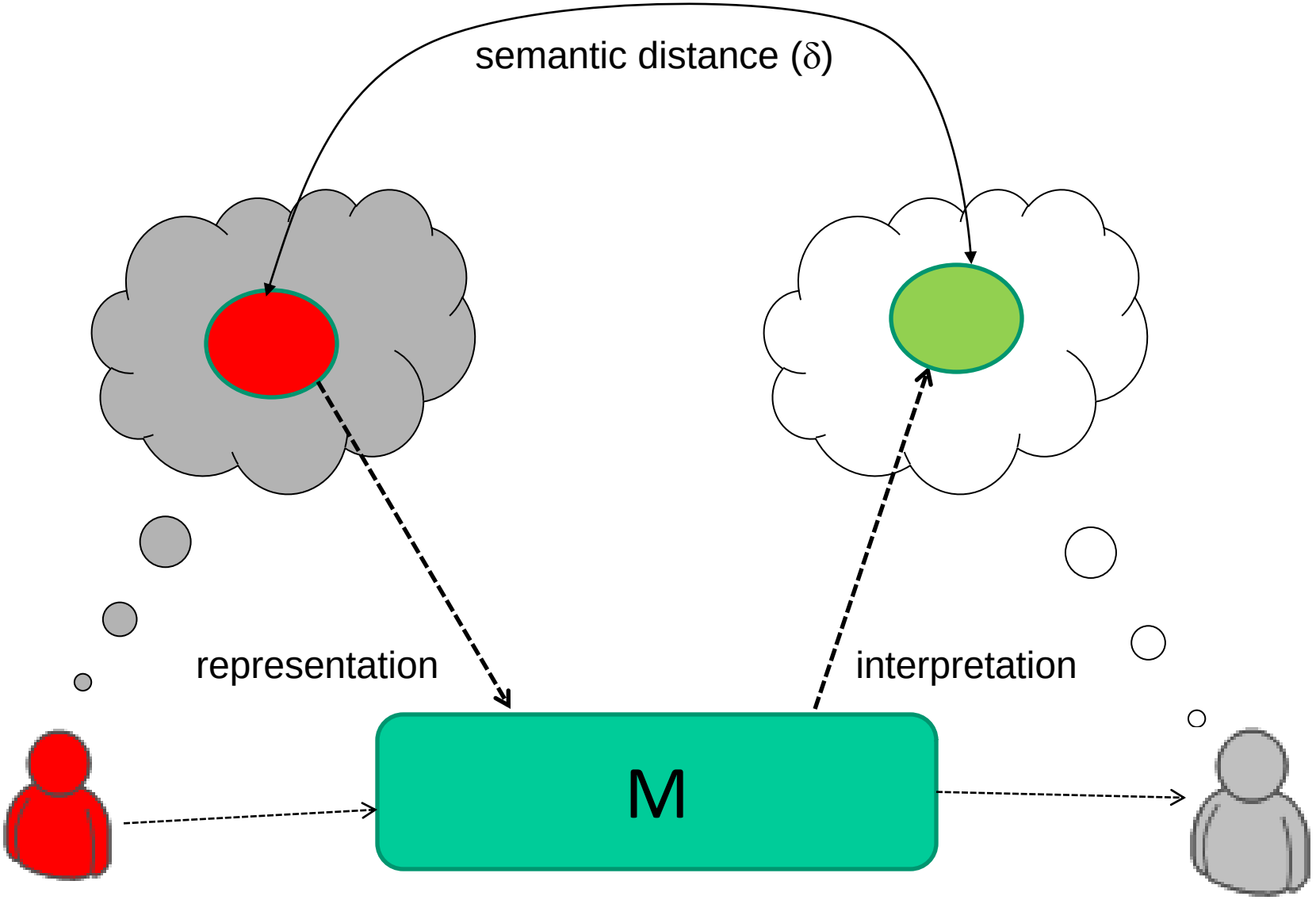
Admissible state of affairs according to the conceptualization underlying O_2



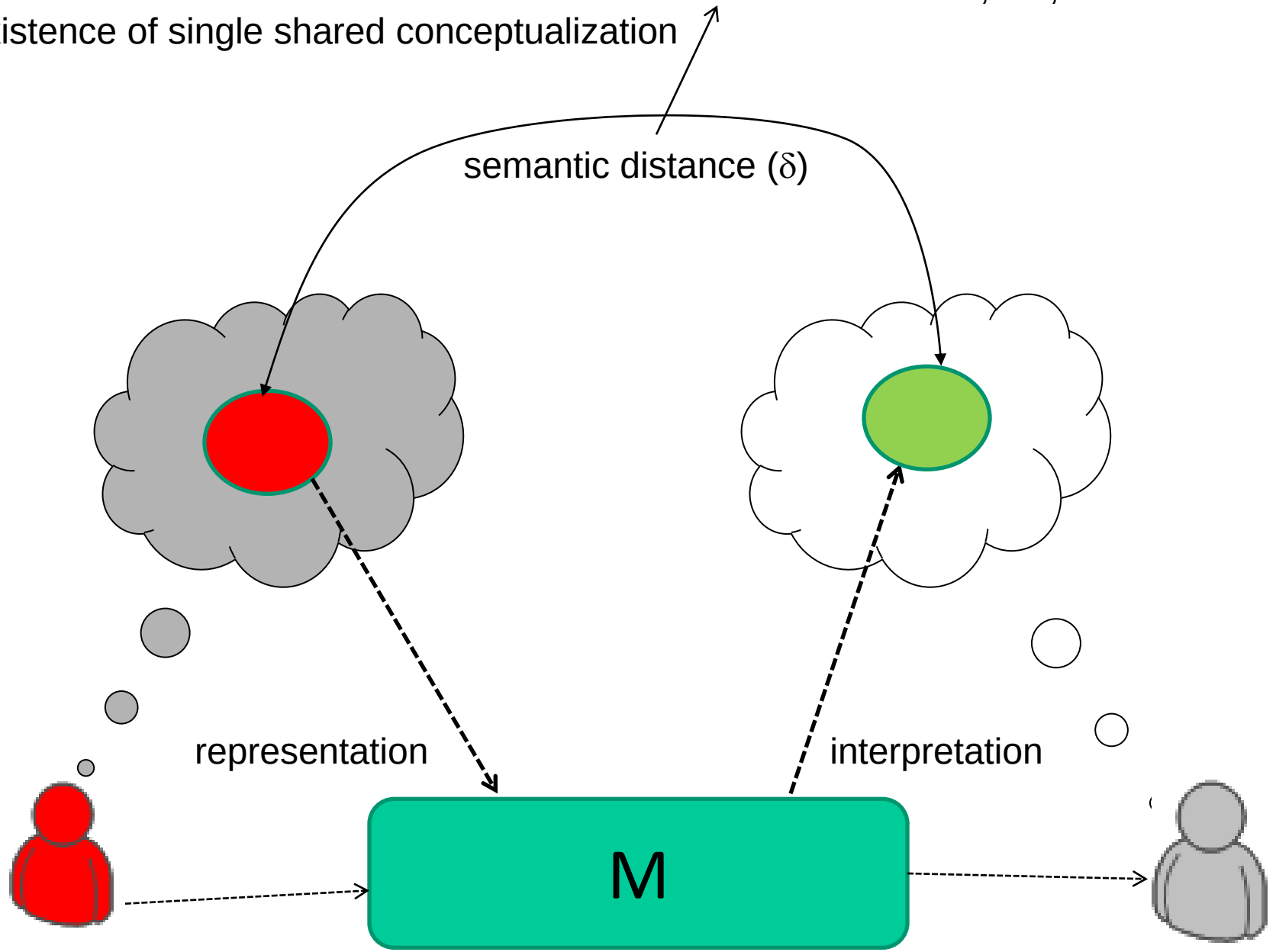
Admissible state of affairs according to the conceptualization underlying O_1

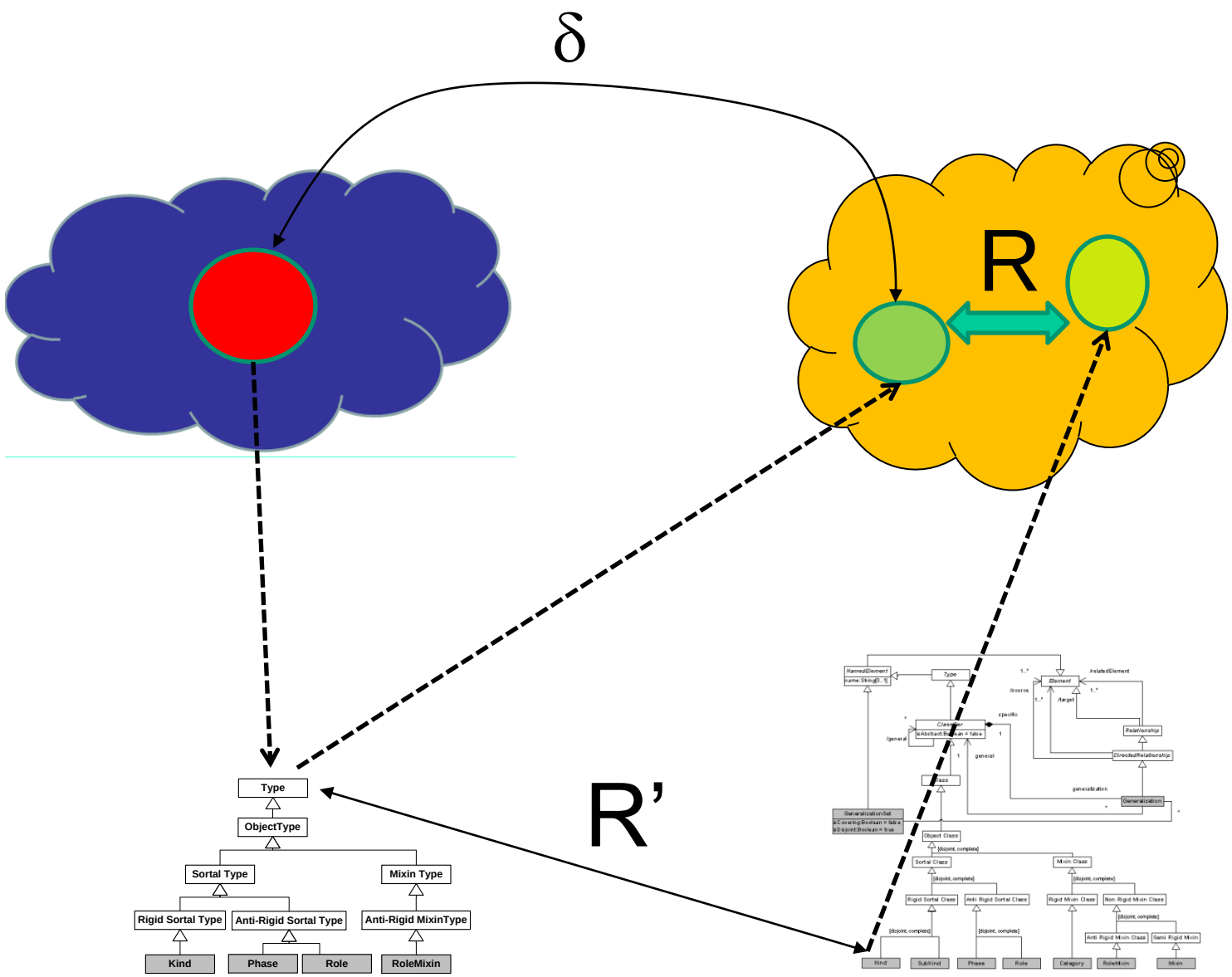
FALSE AGREEMENT!

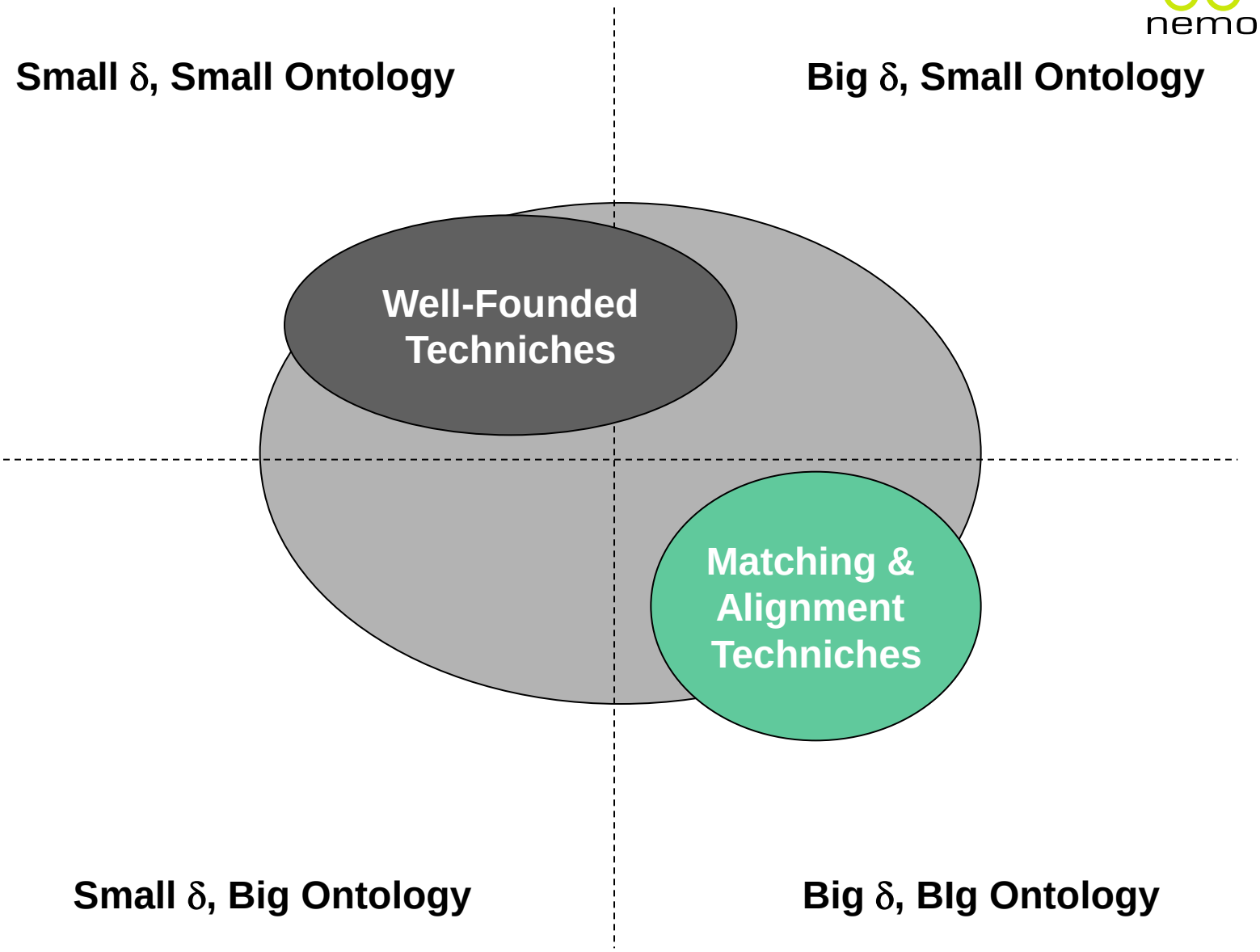

representation
interpretation
M

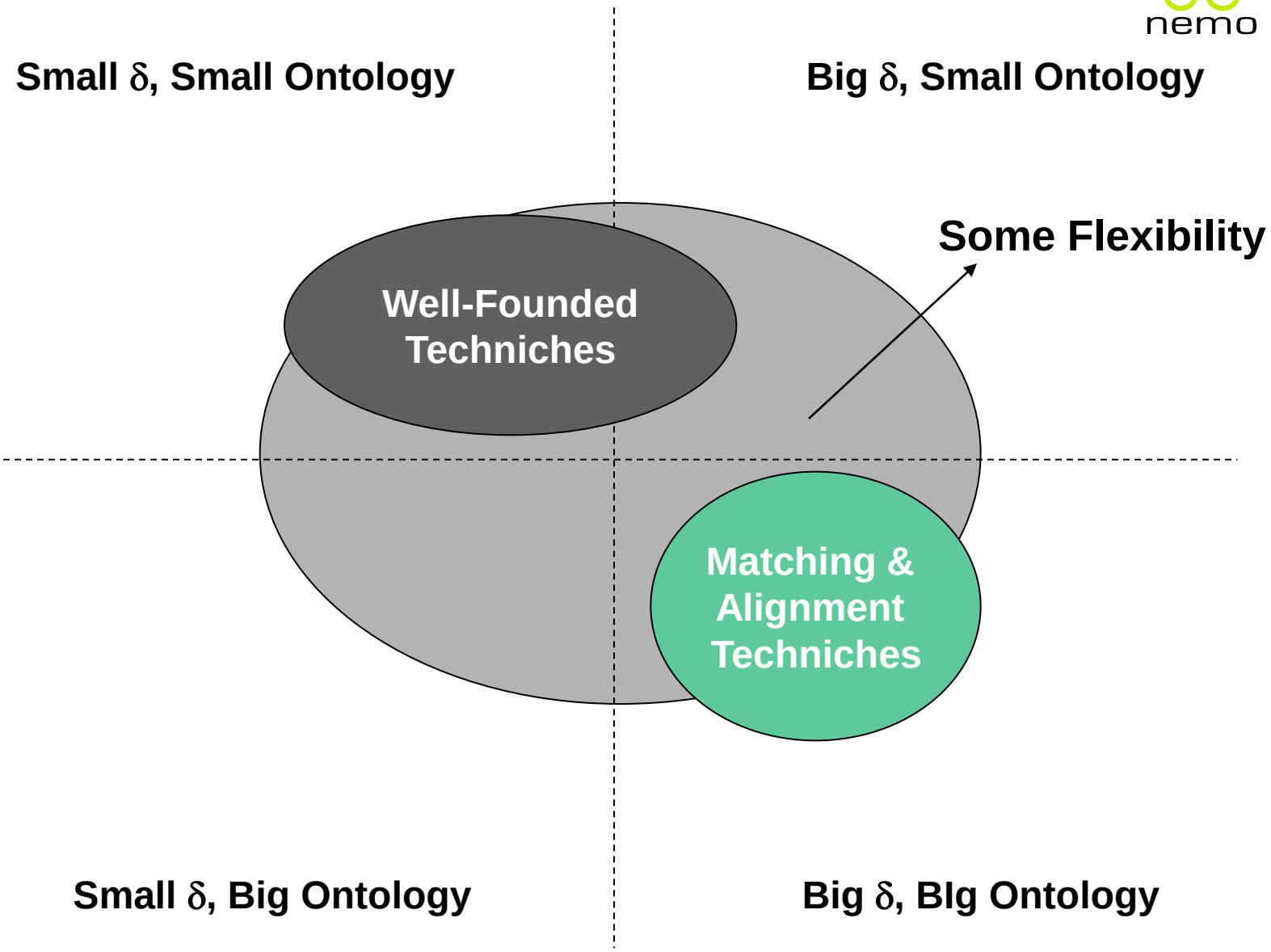

semantic distance (δ)
representation
interpretation
M

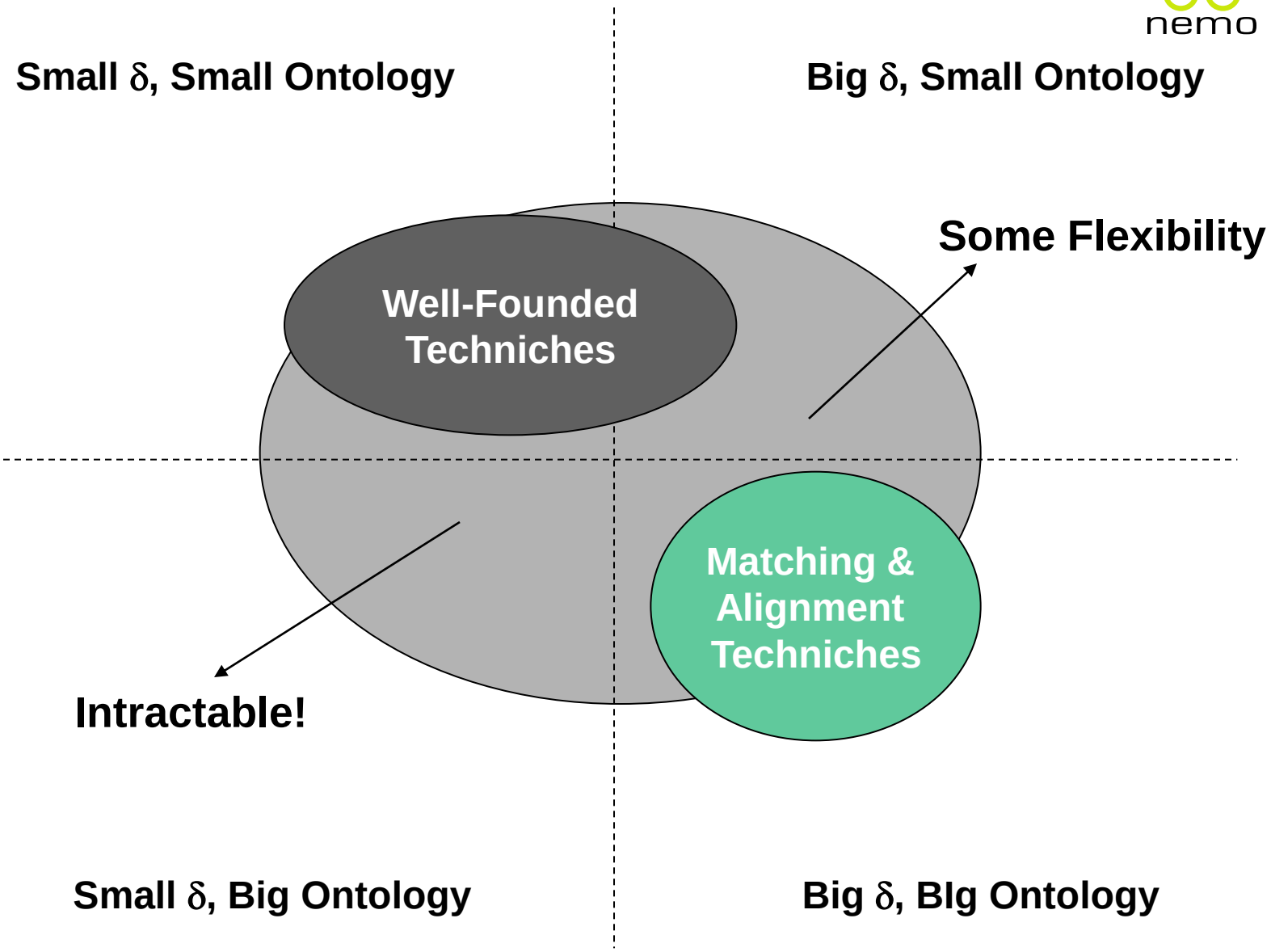
when $\delta < x$ then we consider the communication to be effective, i.e., we assume the existence of single shared conceptualization

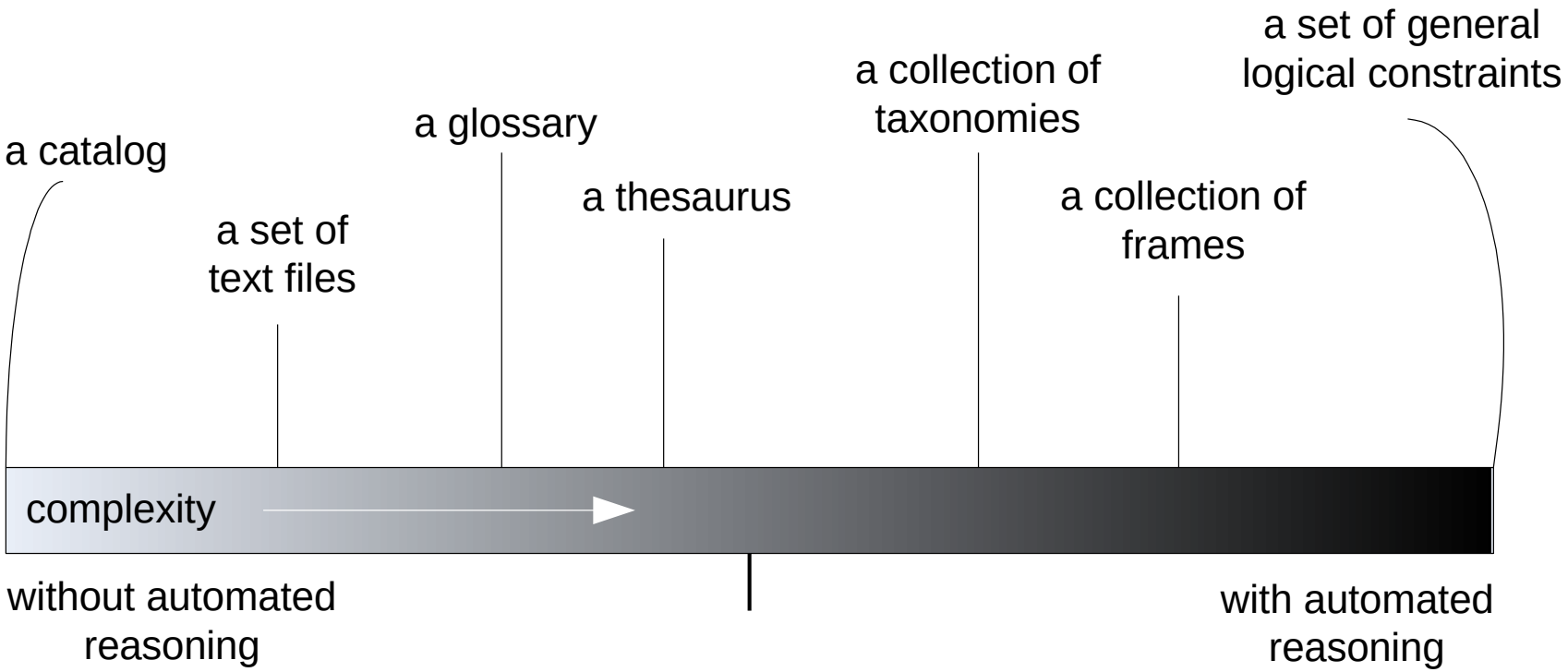



δ
R
R'
Type
ObjectType
Sortal Type
Mixin Type
Rigid Sortal Type
Anti-Rigid Sortal Type
Anti-Rigid MixinType
Kind
Phase
Role
RoleMixin


Small δ, Small Ontology
Big δ, Small Ontology
Well-Founded Techniches
Matching & Alignment Techniches
Small δ, Big Ontology
Big δ, Blg Ontology


Small δ, Small Ontology
Big δ, Small Ontology
Some Flexibility
Well-Founded Techniches
Matching & Alignment Techniches
Small δ, Big Ontology
Big δ, Blg Ontology


Small δ, Small Ontology
Big δ, Small Ontology
Some Flexibility
Well-Founded Techniches
Matching & Alignment Techniches
Intractable!
Small δ, Big Ontology
Big δ, Blg Ontology

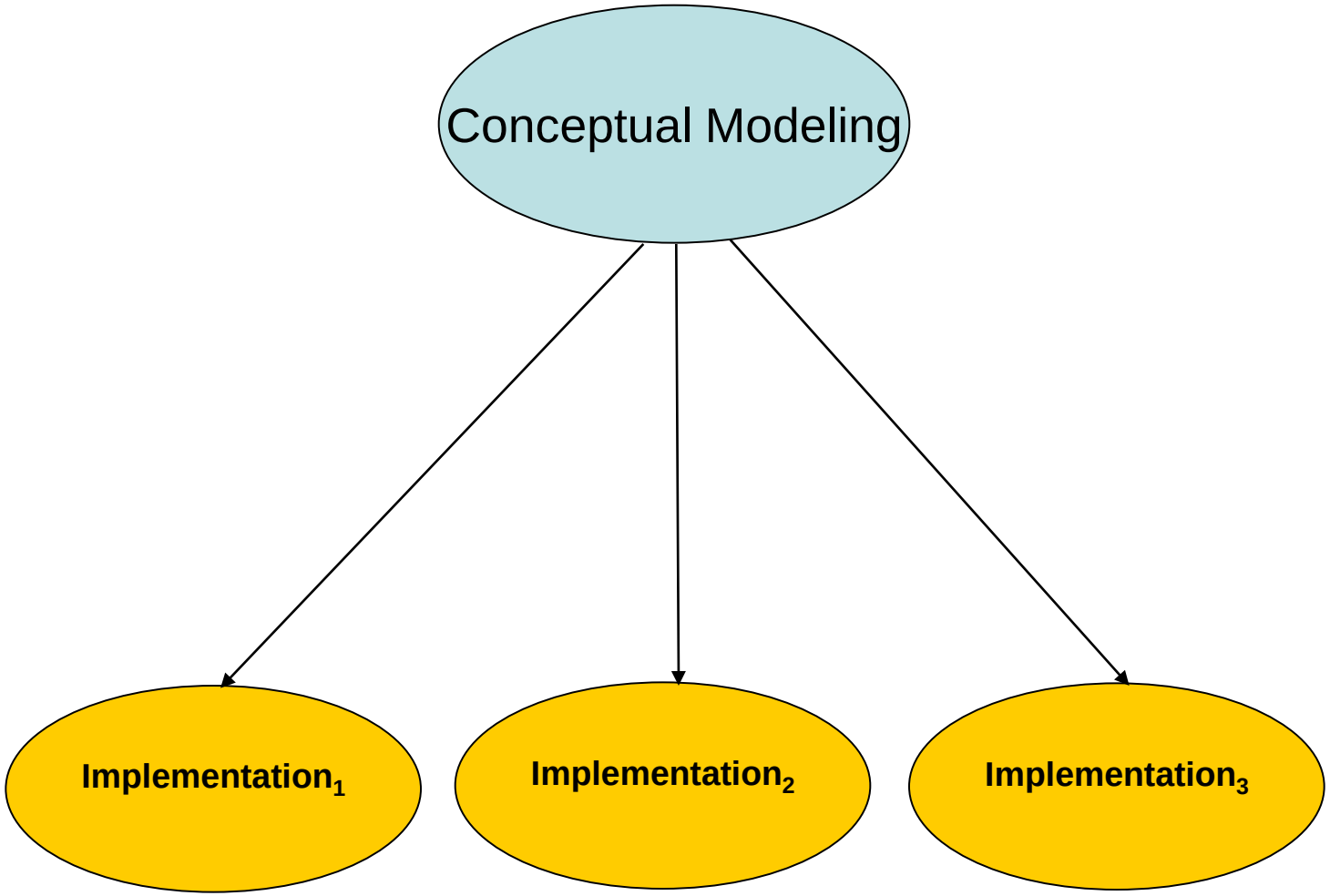

a catalog
a set of
text files
a glossary
a thesaurus
a collection of
taxonomies
a collection of
frames
a set of general
logical constraints
complexity
without automated
reasoning
with automated
reasoning

We need to recognize that *There is not Silver Bullet!* and **start seing ontology engineering from an engineering perspective**

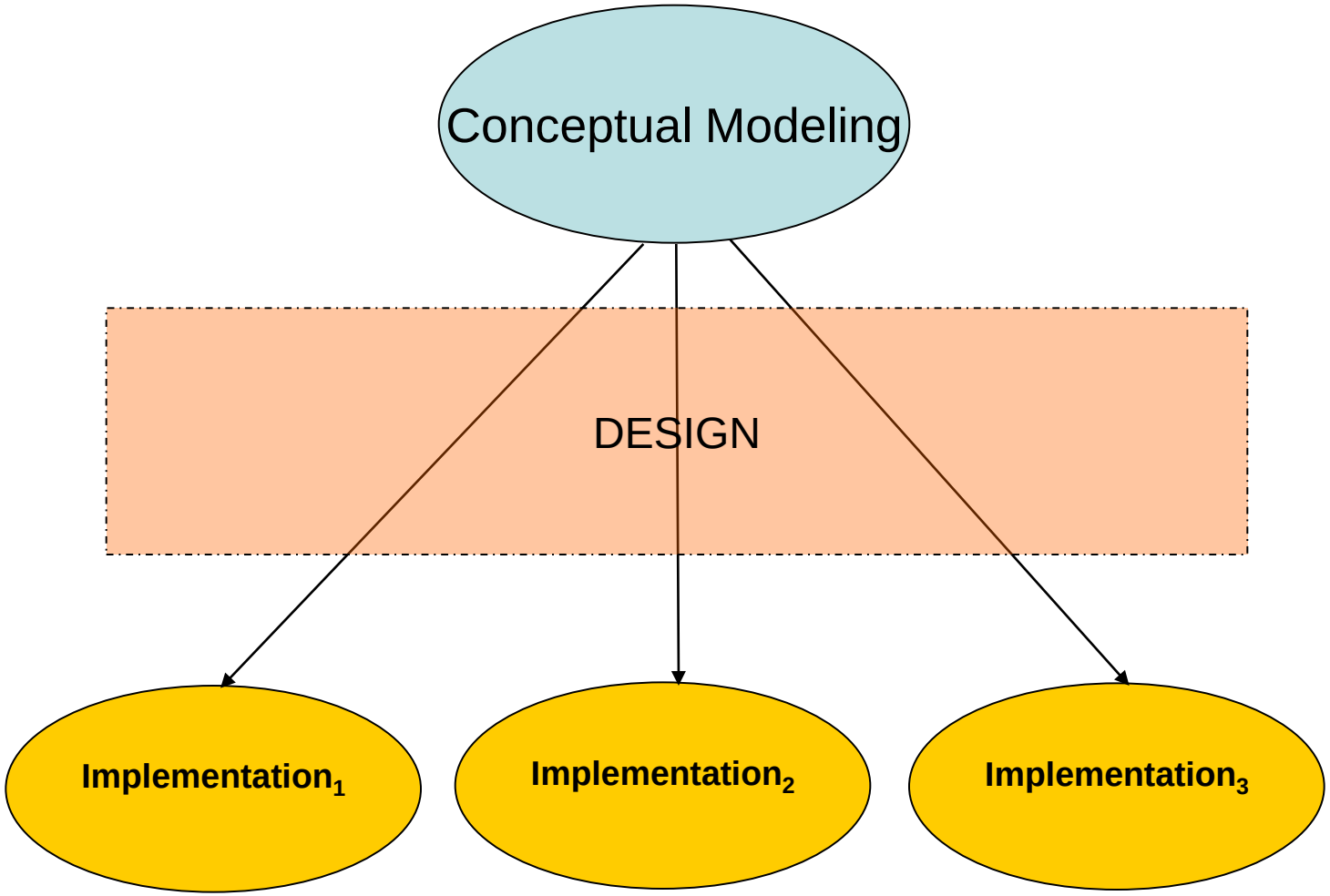
“What are ontologies and why we need them?”

1. *Reference Model of Consensus* to support different types of *Semantic Interoperability* Tasks
2. Explicit, declarative and machine processable artifact coding a domain model to enable efficient automated reasoning

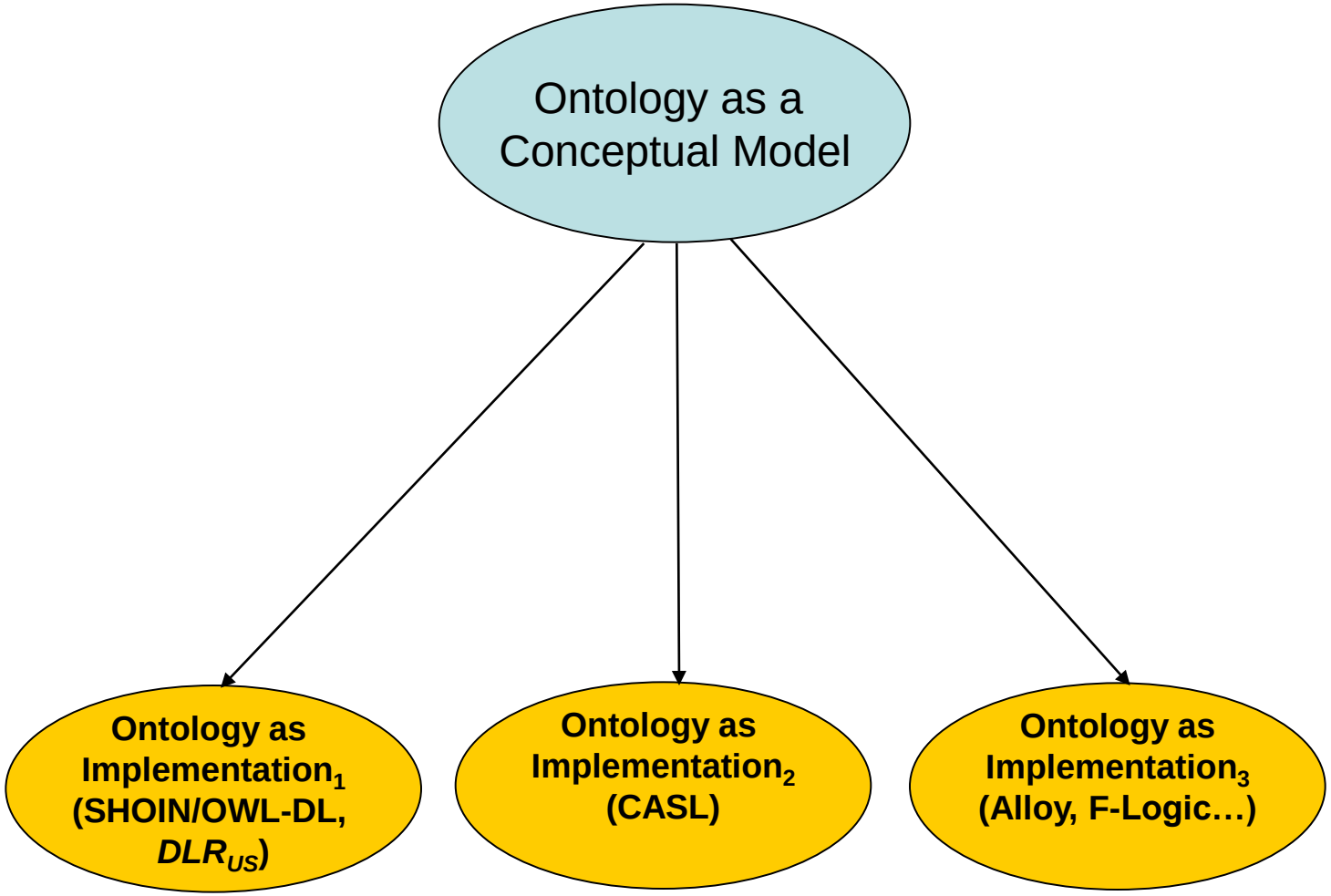
A Software Engineering view…



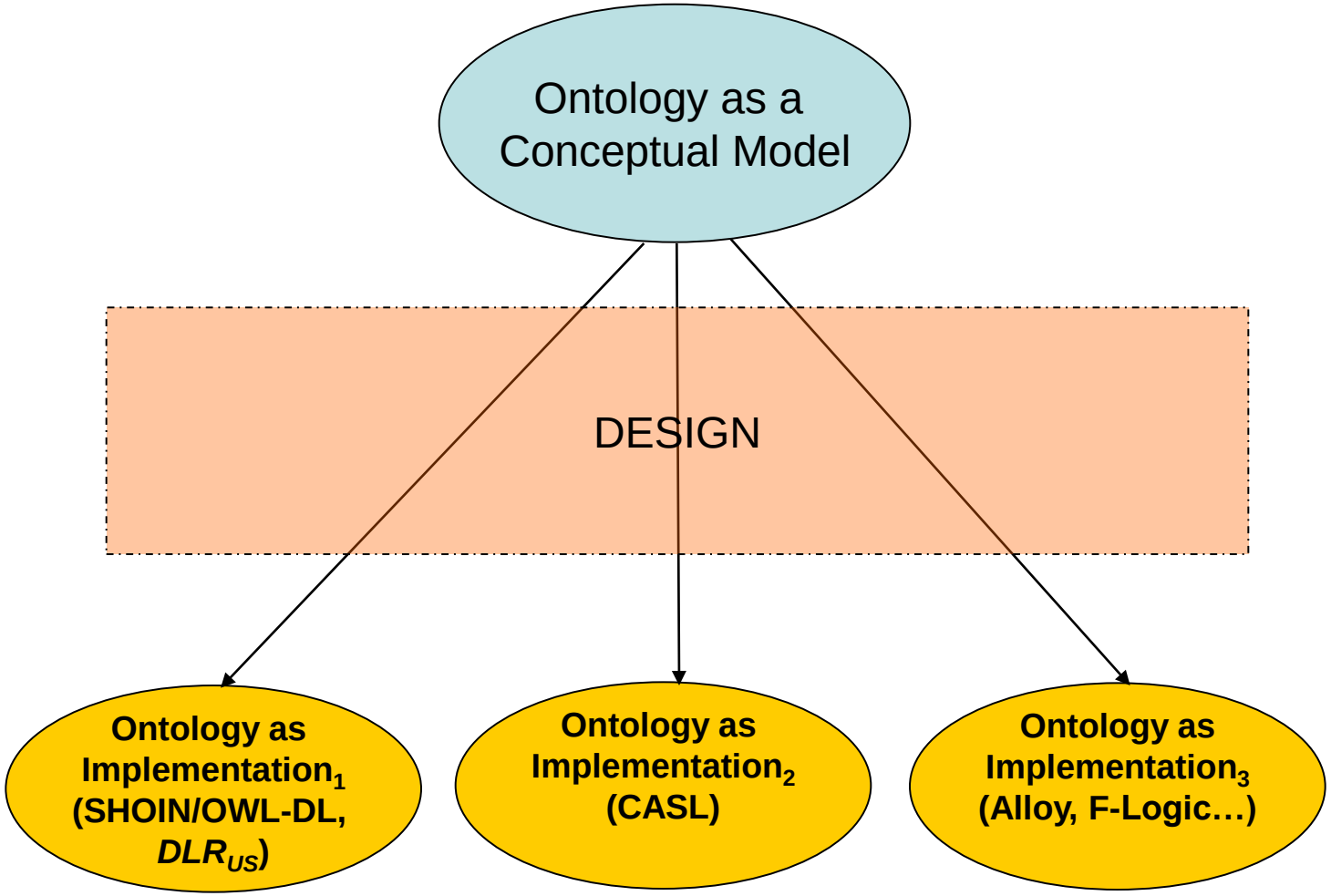
A Software Engineering view…



…transported to Ontological Engineering

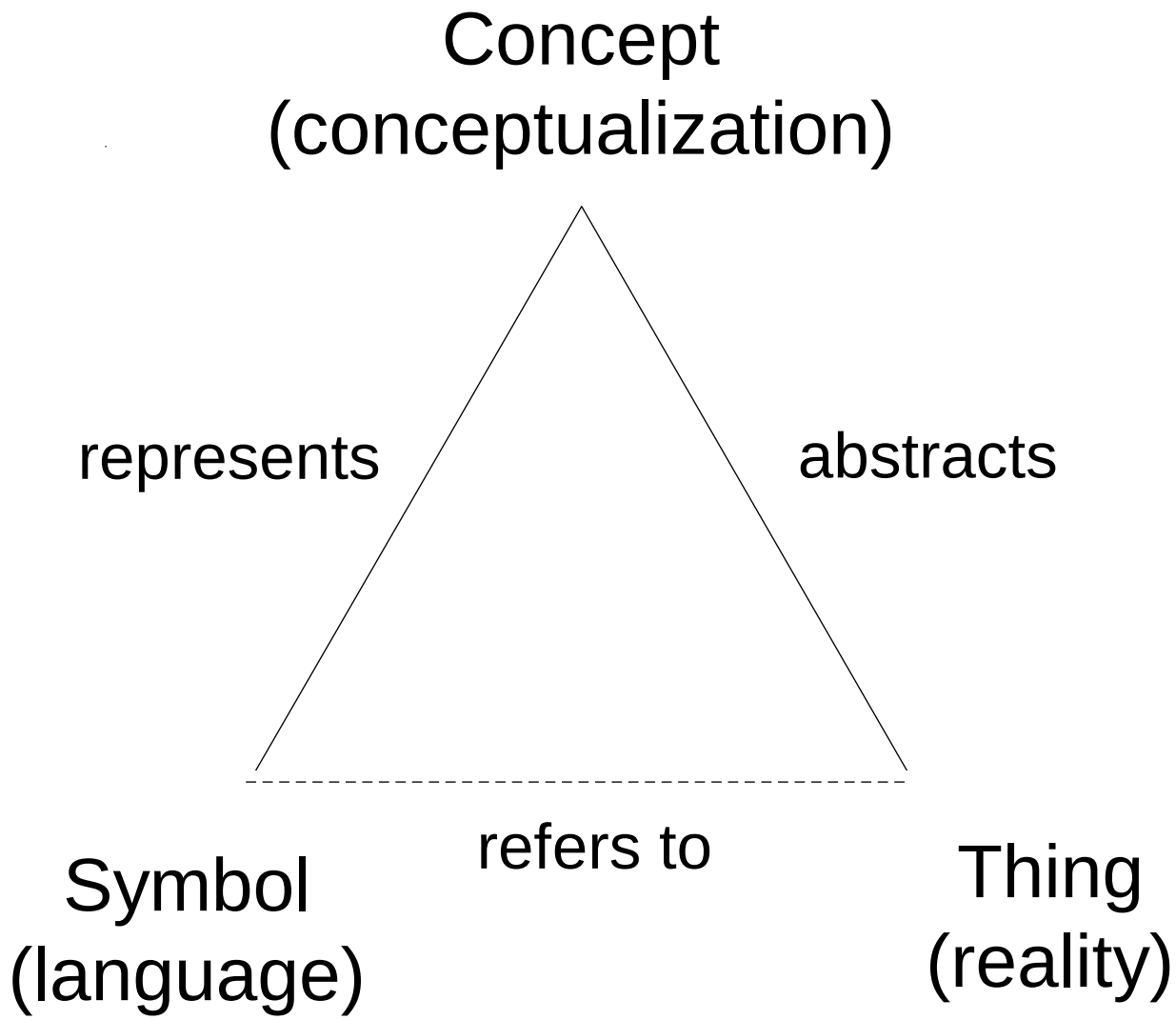


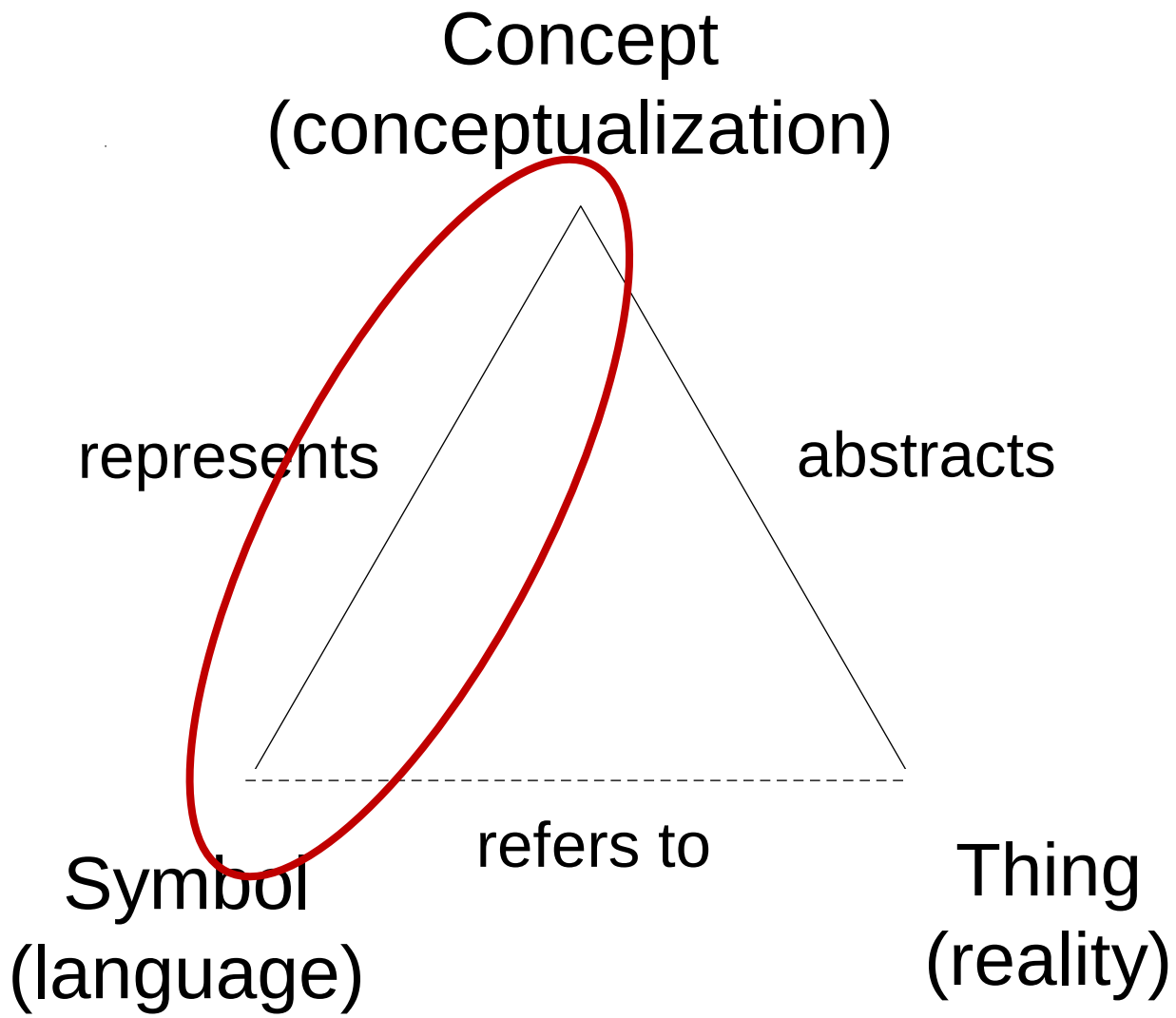
…transported to Ontological Engineering



We need a proper Conceptual Modeling Language

We need a representation system whose system of modeling primitives reflect the distinctions of an appropriate underlying (descriptive) ontology


Concept
(conceptualization)
represents
abstracts
refers to
Symbol
(language)
Thing
(reality)


Concept
(conceptualization)
represents
abstracts
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Symbol
(language)
Thing
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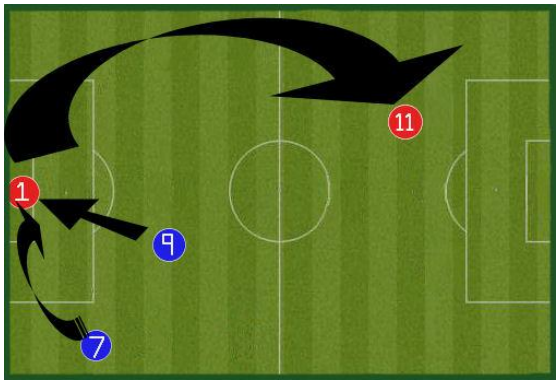
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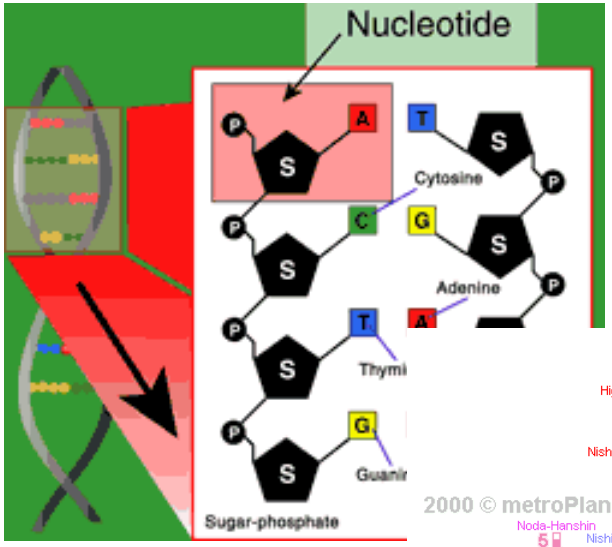
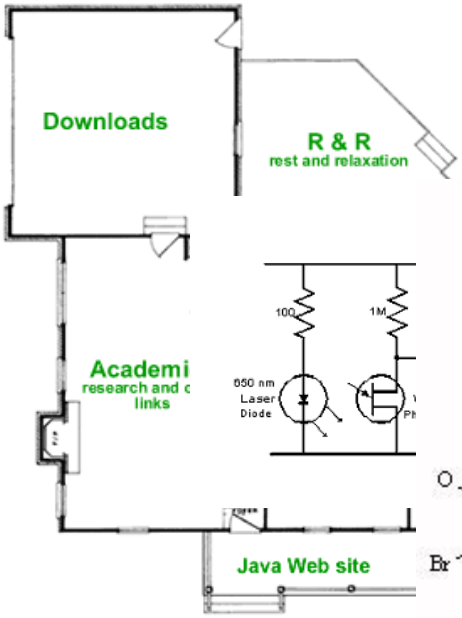
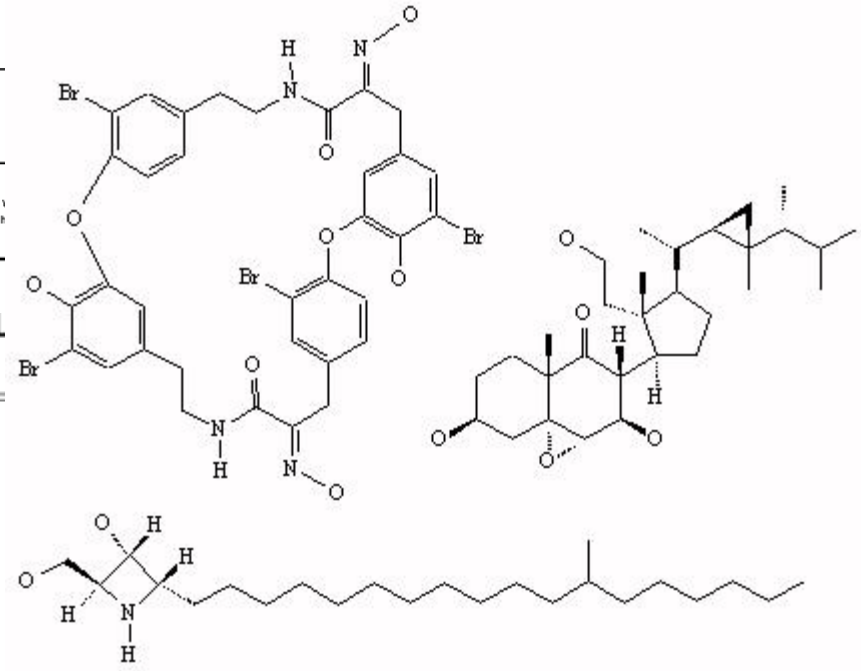
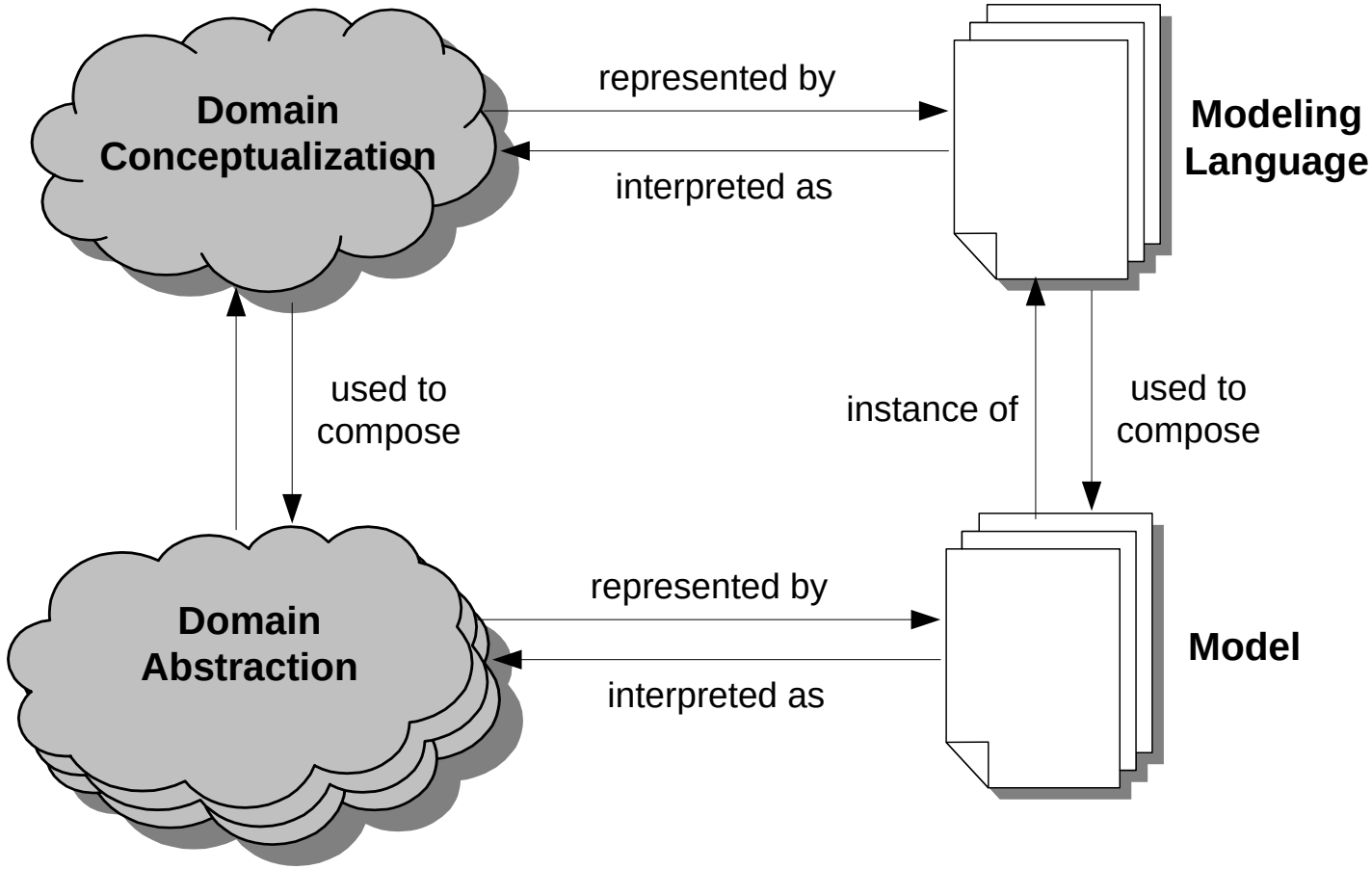
9
7

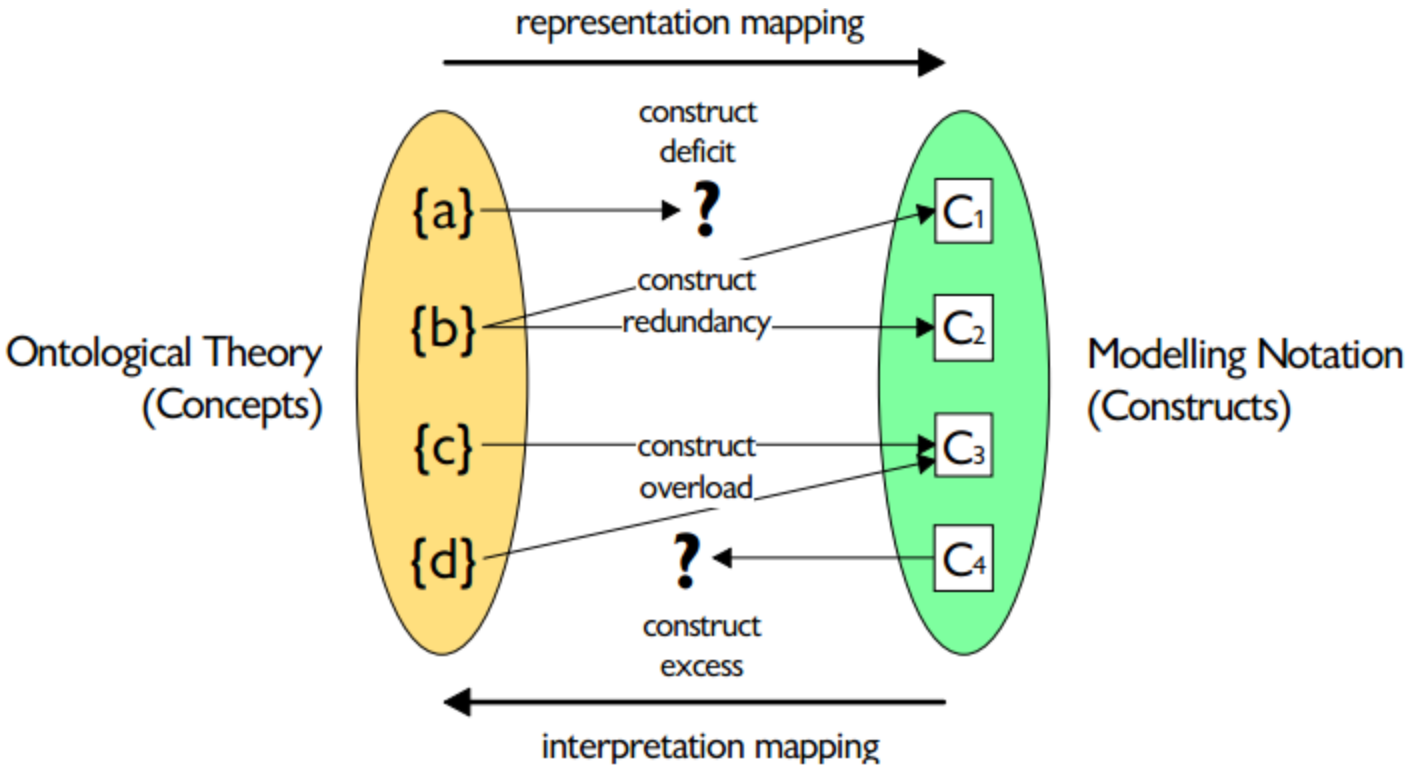

Nucleotide
A
T
C
G
Cytosine
Adenine
Thymi
Guanir
Sugar-phosphate


Downloads
R & R
rest and relaxation
Academi
research and c
links
100
1M
650 nm
Laser
Diode
Java Web site

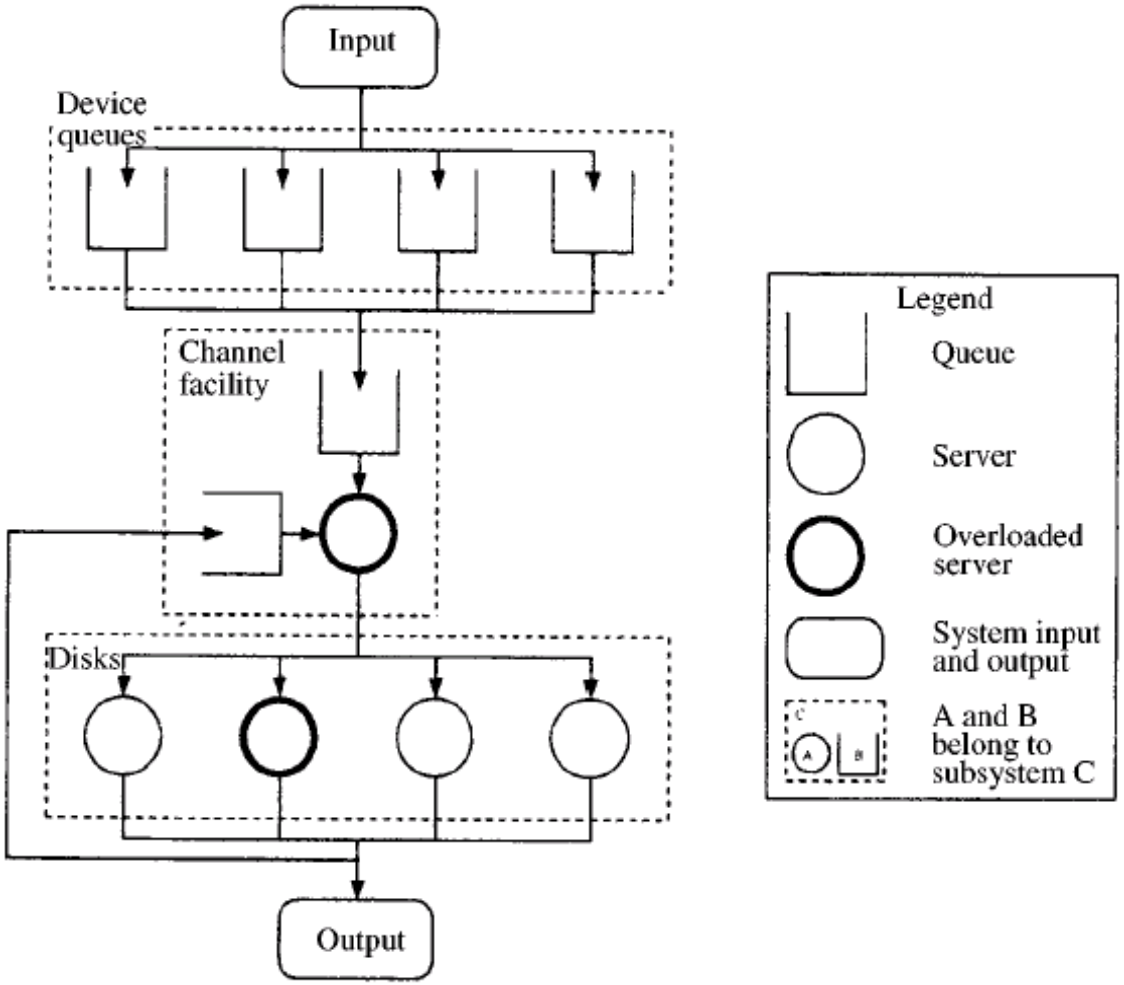


Esaka
Higashi-Mikuni
Shin-Osaka
Nishi-Nakashima
Minamigata
Nakatsu
Noda-Hanshin
Umeda
Nishi-Umeda
Tamagawa
Higobashi
Awaza
Honmachi
Nakazaki-cho
Tenjinbashi-Shisuji-6
Ogimachi
Higashi-umeda
Kita-hama
Yodoyabashi
Sakaisuji-Hommachi
Minami-Morimachi
Kyobashi
Temma-bashi
Tanimachi-4-chome
Shinsaibashi
Naga-horibashi
Tanimachi-6-chome
Nippon-bashi
Tanimachi 9-chome
Namba
Ebisucho
Tennoji
Dobutsuen-mae
Tengachaya
Showacho
Nishi-Tanabe
Nagai
Abiko
Kitahanada
Shin-Kanaoka
Nakamozu
Itakano
Zuiko
Toyosato
Dainichi
Moriguchi
Taishibashi-Imaichi
Senyabashi-Omiya
Shimizu
Sekime
Miyakojima
Koichi
Kadoma-Minami
Noe
Uchindai
Gamo-4-chome
Yoko-zutsumi
Tsurumi-Ryokuchi
Imafuku-Tsurumi
Shigino
Osaka Business Park
Fukaebashi
Nagata
Takaida
Midoribashi
Morinomiya
Tamatsukuri
Shin-Fukae
Imazato
Shoji
Kita-Tatsumi
Minami-Tatsumi
Tsuruhashi
Shintennoji-mae
Abeno
Fuminosato
Tanabe
Komagawa-Nakano
Hirano
Kire-Uriwari
Deto
Nagahara
Yao-Minami
2000 © metroPlanet

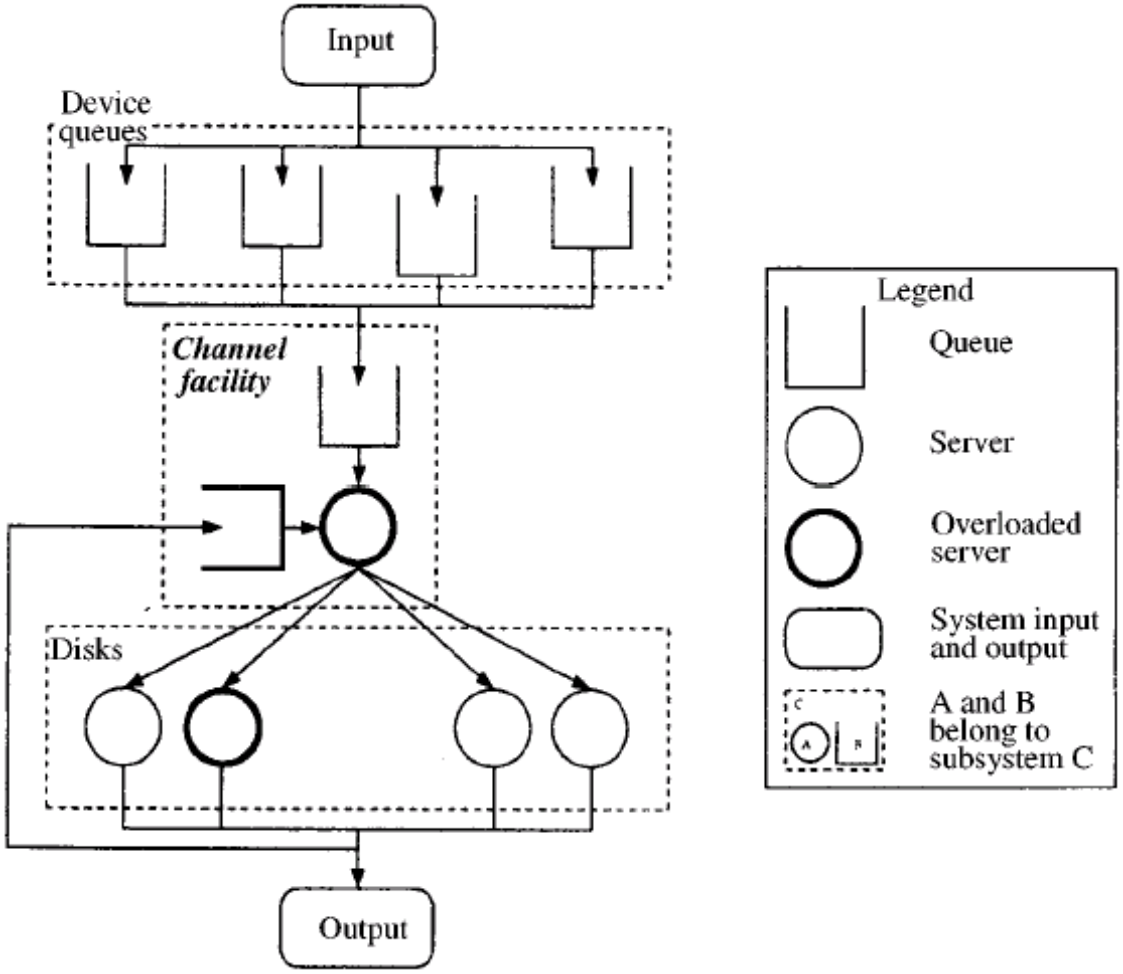

Domain
Conceptualization
represented by
interpreted as
Modeling
Language
used to
compose
instance of
used to
compose
Domain
Abstraction
represented by
interpreted as
Model



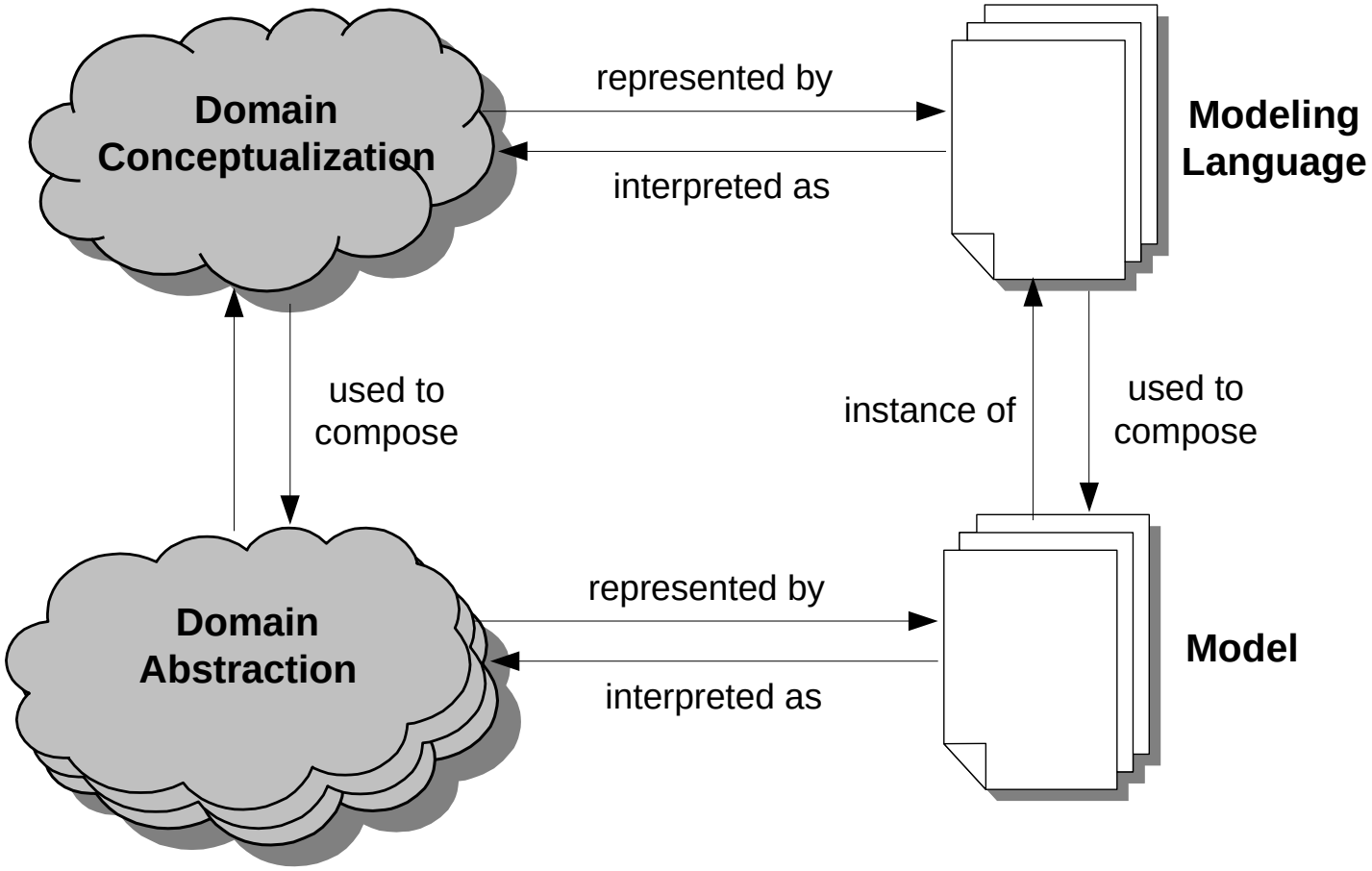
Picture by Daniel Moody

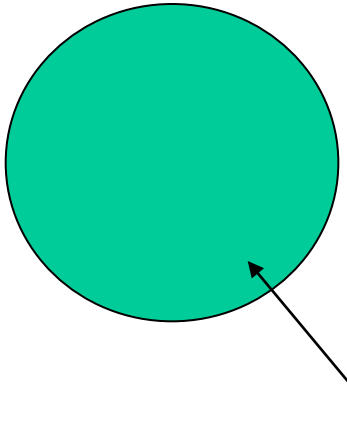


by Marks and Reiter, 1990



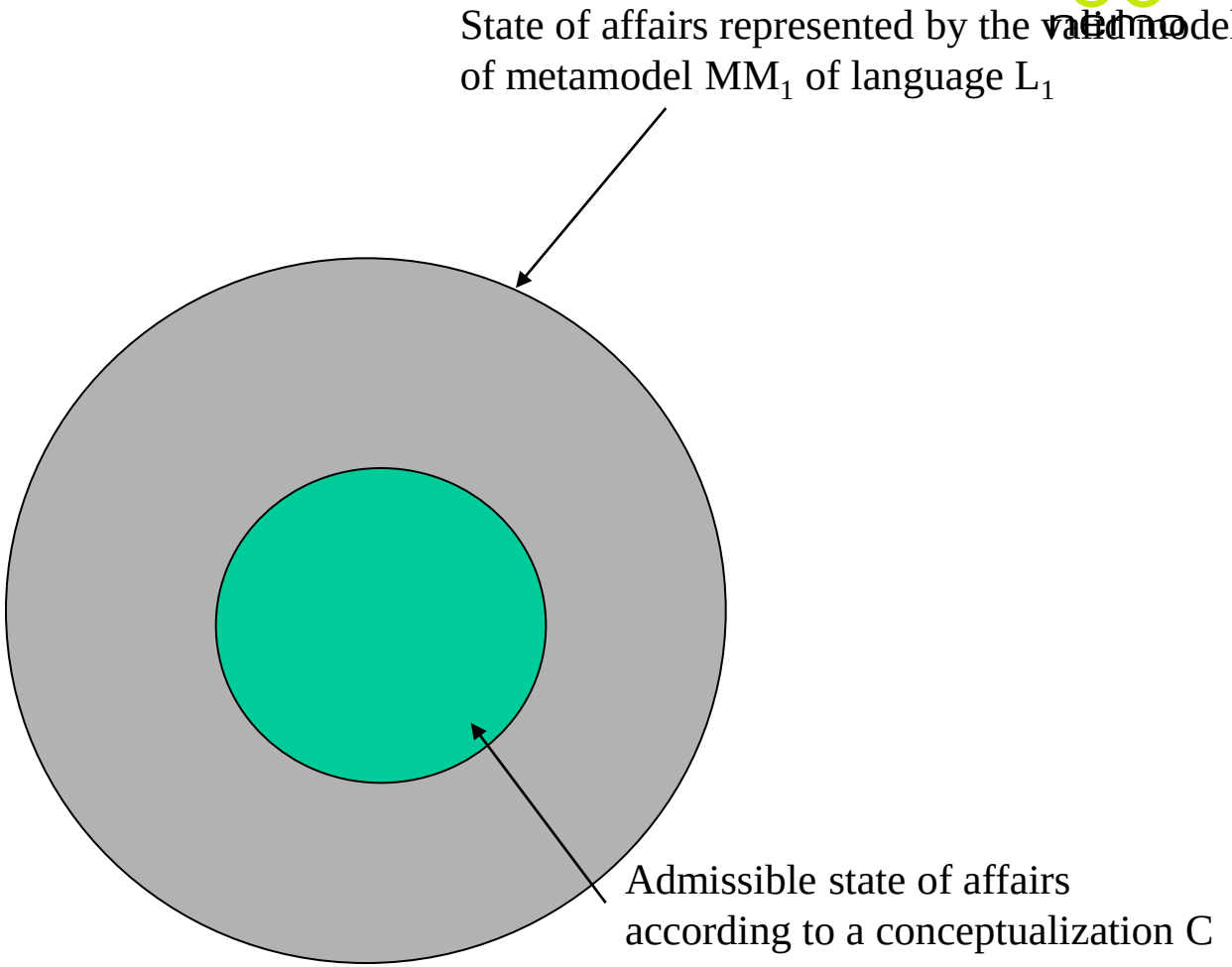
by Marks and Reiter, 1990


Domain
Conceptualization
represented by
interpreted as
Modeling
Language
used to
compose
instance of
used to
compose
Domain
Abstraction
represented by
interpreted as
Model



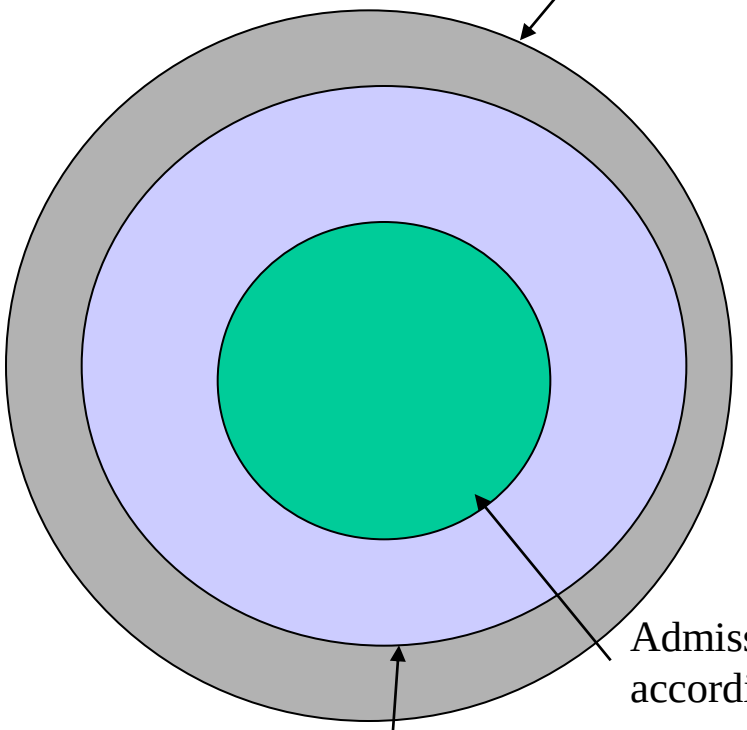
Admissible state of affairs
according to a conceptualization C

{∃x Person(x), ∃x Father(x)} (MM_1)


State of affairs represented by the valid models of metamodel MM_1 of language L_1
Admissible state of affairs according to a conceptualization C

$\{\exists x\ Person(x), \exists x\ Father(x)\}$ (MM_1)

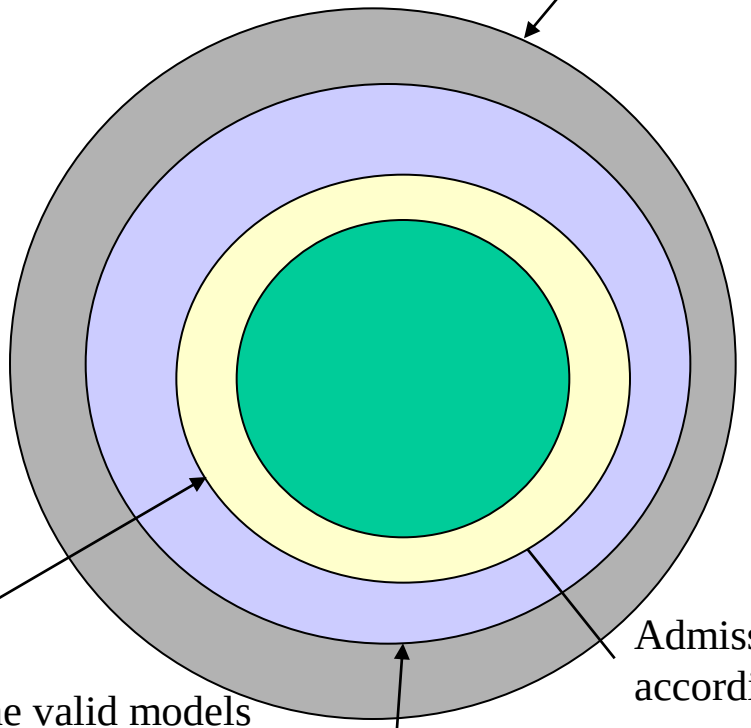
$\{\exists x\ Person(x), \exists x\ Father(x), \forall x\ Father(x) \rightarrow Man(x), \forall x\ Person(x) \leftrightarrow Man(x) \vee Woman(x), \neg\exists x\ Man(x) \wedge Woman(x), \ldots\}$ (MM_2)

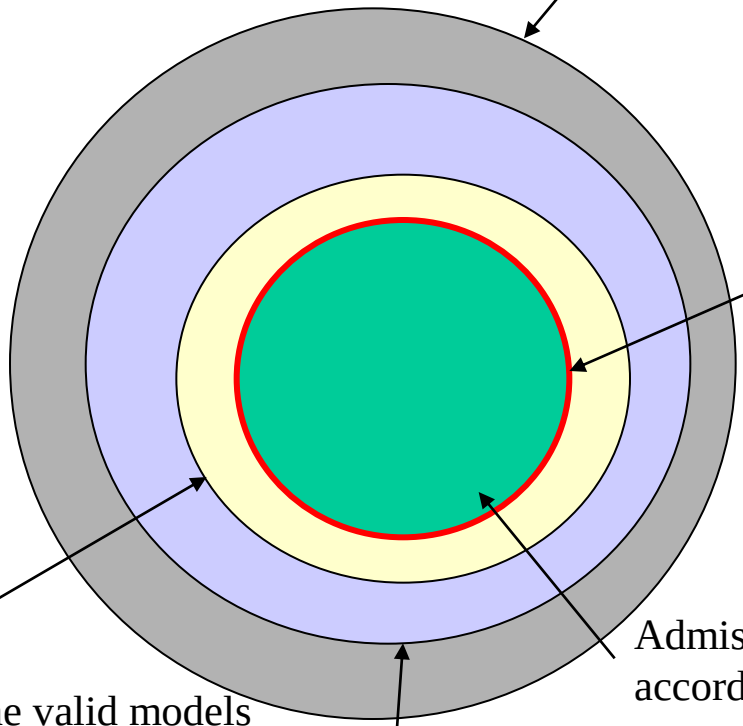

State of affairs represented by the valid models
of metamodel MM_1 of language L_1
Admissible state of affairs
according to a conceptualization C
State of affairs represented by the valid models
of metamodel MM_2 of language L_2

$\{\exists x\ Person(x), \exists x\ Father(x)\}$ (MM_1)

$\{\exists x\ Person(x), \exists x\ Father(x), \forall x\ Father(x) \rightarrow Man(x), \forall x\ Person(x) \leftrightarrow Man(x) \vee Woman(x), \neg\exists x\ Man(x) \wedge Woman(x), \ldots\}$ (MM_2)

$\{\exists x\ Person(x), \exists x\ Father(x), \forall x\ Father(x) \rightarrow Man(x), \forall x\ Person(x) \leftrightarrow Man(x) \vee Woman(x), \neg\exists x\ Man(x) \wedge Woman(x), \forall x\ Person(x) \rightarrow \Box Person(x), \forall x\ LivingPerson(x) \rightarrow \Diamond\neg LivingPerson(x) \ldots\}$ (MM_3)


State of affairs represented by the valid models of metamodel MM_1 of language L_1
Admissible state of affairs according to a conceptualization C
State of affairs represented by the valid models of metamodel MM_3 of language L_3
State of affairs represented by the valid models of metamodel MM_2 of language L_2


State of affairs represented by the valid models of metamodel MM_1 of language L_1
Ontology of the domain according to the conceptualization C
Admissible state of affairs according to a conceptualization C
State of affairs represented by the valid models of metamodel MM_3 of language L_3
State of affairs represented by the valid models of metamodel MM_2 of language L_2

Additional References

1. Guizzardi, G., Halpin, T. Ontological Foundations for Conceptual Modeling. Applied Ontology. , v.3, p.91 - 110, 2008.
2. Guizzardi, G., On Ontology, ontologies, Conceptualizations, Modeling Languages, and (Meta)Models, Frontiers in Artificial Intelligence and Applications, Databases and Information Systems IV, Olegas Vasilecas, Johan Edler, Albertas Caplinskas (Editors), ISBN 978-1-58603-640-8, IOS Press, Amsterdam, 2007.
3. Guizzardi, G.; Ferreira Pires, L.; van Sinderen, M. An Ontology-Based Approach for Evaluating the Domain Appropriateness and Comprehensibility Appropriateness of Modeling Languages, Lecture Notes in Computer Science LNCS 3713, Springer-Verlag, 2005.

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