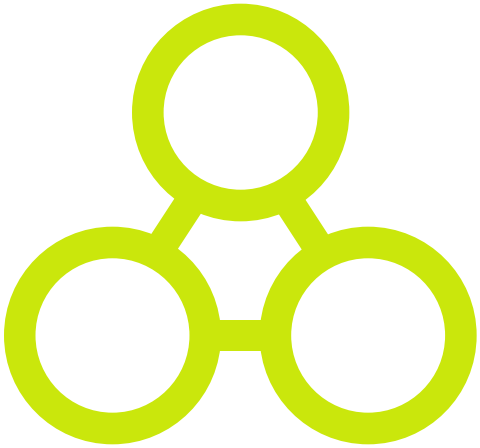
Introduction to Ontological Engineering



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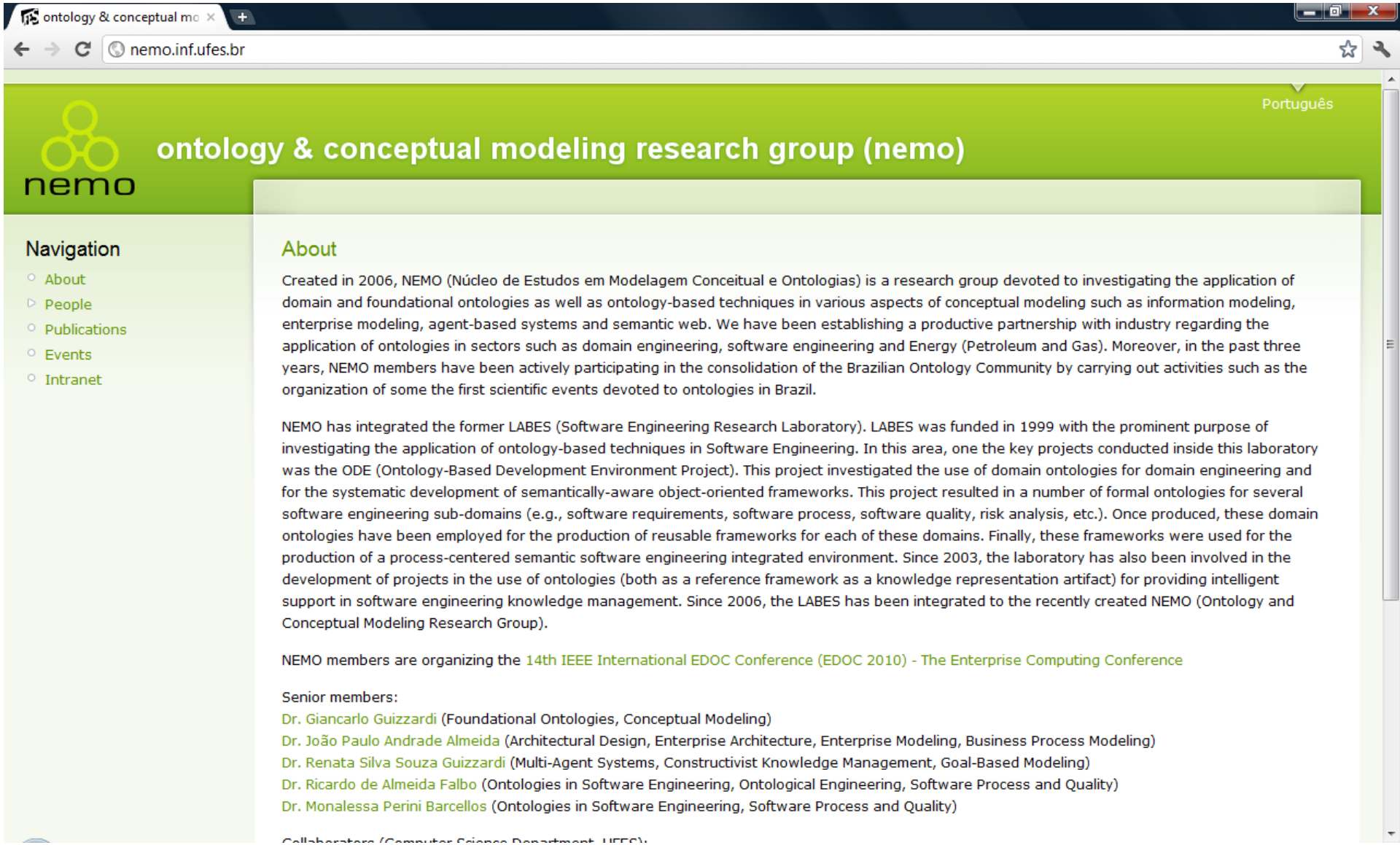
ontology & conceptual modeling research group

Giancarlo Guizzardi

gguizzardi@acm.org

Workshop W3C/SLTI
Brasília, Brazil
July, 13th 2011



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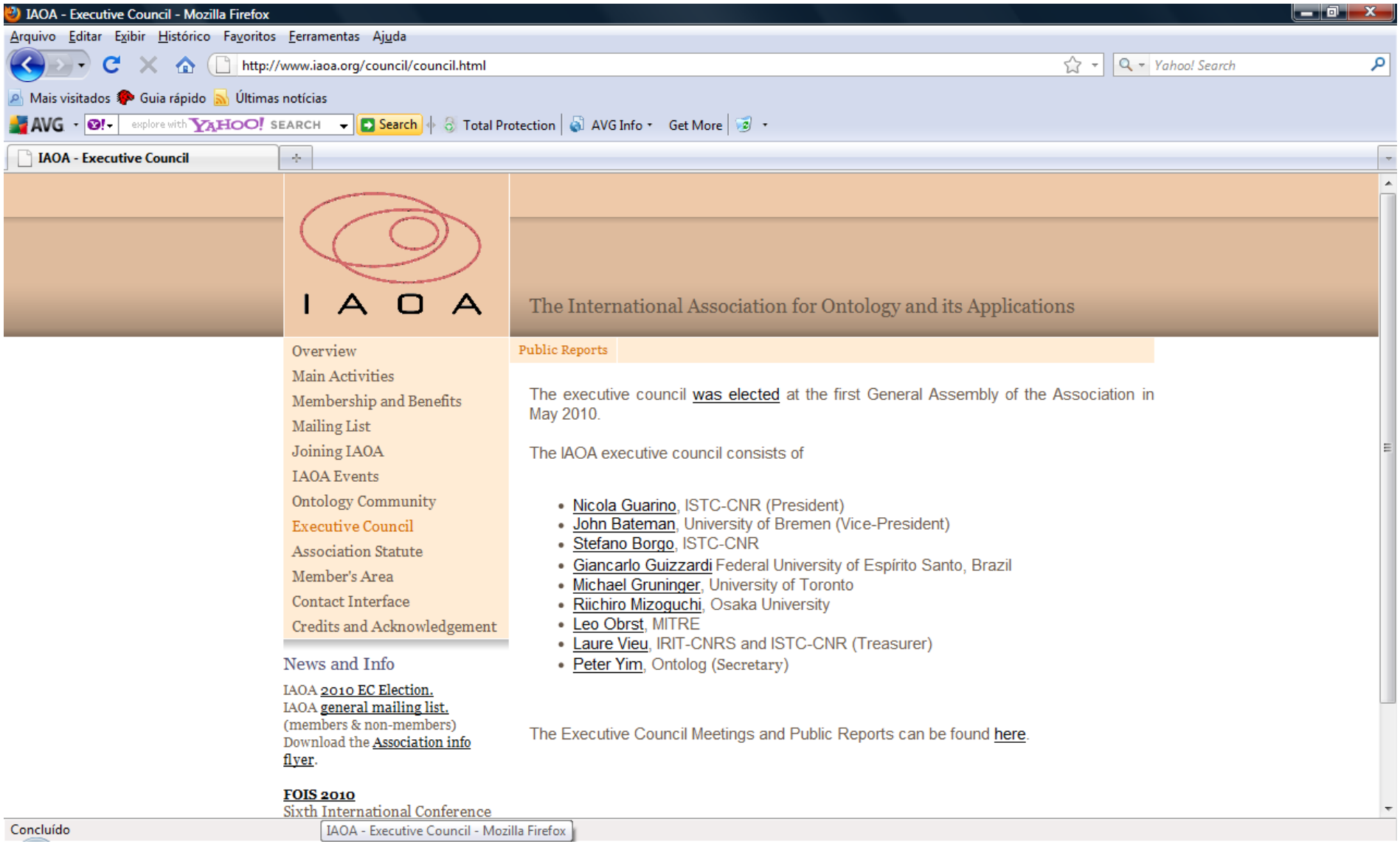

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(2JZ8)
6th in the series of a 3-month open annual event, by and for the Ontology Community. This Summit is co-organized by Ontolog, NIST, NCOR, NCBO, IAOA & NCO_NITRD (2JZ9)
ref. OntologySummit & OntologySummit2011_Communique (2JZD)
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www.inf.ufes.br/~gguizzardi/ontocom-2011/

International Workshop on Ontologies and Conceptual Modeling

Onto.Com 2011

together with the

I A O A

30th International Conference on Conceptual Modeling (ER 2011)
organized by the SIG on Ontologies and Conceptual Modeling of the
International Association for Ontologies and Applications

PURPOSE AND SCOPE

There has been a growing interest in the role played by formal ontology, as well as areas such as philosophical logics, cognitive sciences and linguistics, in the development of theoretical foundations for conceptual modeling. In particular, a number of ontological theories such as BWW, DOLCE, GFO and UFO have been successfully applied to the evaluation of conceptual modeling languages and frameworks (e.g., UML, ORM, ER, REA, TROPOS, ARIS, BPMN, RM-ODP, Archimate and OWL), and to the development of engineering tools (e.g., methodological guidelines, modeling profiles, design patterns) that contribute to the theory and practice of this discipline.

Additionally, there has been an increasing interest in the use of empirical studies to assess the impact of the application of these theoretical foundations to the design of conceptual modeling grammars and tools. The objective of this workshop is to collect innovative and high-quality research contributions regarding the role played by the aforementioned disciplines to the foundations of conceptual modeling.

With this workshop we would like to create a true forum for discussion and, in that spirit, we would like to solicit papers that address specific questions of relevance to body of knowledge of the emerging discipline of Ontology-Driven Conceptual Modeling.

WE PARTICULARLY WELCOME PAPERS THAT RAISE CHALLENGING QUESTIONS, INNOVATIVE IDEAS AND "OUT OF THE BOX" THINKING

http://www.inf.ufes.br/~gguizzardi/ontocom-2011/

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AN ENGINEERING VIEW ON ONTOLOGICAL ENGINEERING

Scenario 1: Information Exchange

Suppose a consortium of enterprises that needs to exchange information in the context of a coordinated action?

How to guarantee the preservation of the original meaning of the information across partners?

How to guarantee this inside an organization?

E.g.: Petroleum Industry (IIP - Integrated Information Platform)

Scenario 2: Component Integration in heterogeneous scenarios

Suppose and Organization that needs to configure a new product/platform/service from already existing and tested components (applications, products, services)

E.g.m: Service Integration, Integrated Development Environments

Scenario 3: Information Integration

Suppose an Organization that needs to have an integrated view of the information which is produced in its organizational units in a concurrent and distributed manner

E.g.,: Intelligent Decision Making; Business Intelligence; Knowledge and Integration Management; E-Government

e-PING — Programa de ...

http://www.governoeletronico.gov.br/acoes-e-projetos/e-ping-padroes-de-interoperabilidade

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Projetos

- Computadores para Inclusão
- e-MAG
- e-PING
  - Grupos de Trabalho
  - GT Interconexão
  - GT Segurança
  - GT Meios de Acesso
  - GT Organização e Intercâmbio de Informações
  - GT Áreas de Integração para e-Gov
  - Fale Conosco
  - Quem é Quem
  - Versões do Documento da e-PING
  - Histórico
  - Arquivos
  - Catálogo de Interoperabilidade
  - Lista de Assuntos do Governo - LAG
  - Guia de Interoperabilidade

Um nível acima

Padrões de Interoperabilidade de Governo Eletrônico

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A arquitetura e-PING – Padrões de Interoperabilidade de Governo Eletrônico – define um conjunto mínimo de premissas, políticas e especificações técnicas que regulamentam a utilização da Tecnologia de Informação e Comunicação (TIC) no governo federal, estabelecendo as condições de interação com os demais Poderes e esferas de governo e com a sociedade em geral.

A construção da arquitetura, inicialmente restrita ao governo federal – Poder Executivo, está sendo coordenada pelos seguintes órgãos:

- Secretaria de Logística e Tecnologia da Informação do Ministério do Planejamento (SLTI/MP);
- Instituto Nacional de Tecnologia da Informação, da Presidência da República (ITI/PR);
- SERPRO, empresa pública do Ministério da Fazenda.

A iniciativa contou com a participação e a colaboração de uma série de órgãos do Poder Executivo Federal, tanto na gestão como na realização dos trabalhos técnicos de montagem da arquitetura. As áreas cobertas pela e-PING estão

e-PING — Programa de ...

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VII - utilização de linguagem simples e compreensível, evitando o uso de siglas, jargões e estrangeirismos; e

VIII - articulação com Estados, Distrito Federal, Municípios e outros poderes para a integração, racionalização, disponibilização e simplificação de serviços públicos prestados ao cidadão.

Art. 2º Os órgãos e entidades do Poder Executivo Federal que necessitarem de documentos comprobatórios de regularidade de situação do cidadão, atestados, certidões ou outros documentos comprobatórios que constem em base de dados oficial da administração pública federal deverão obtê-los diretamente do respectivo órgão ou entidade.

Parágrafo único. Exclui-se da aplicação do disposto no **caput**:

I - comprovação de antecedentes criminais;

II - informações sobre pessoa jurídica; e

III - situações expressamente previstas em lei.

Art. 3º Os órgãos e entidades do Poder Executivo Federal não poderão exigir do cidadão a apresentação de certidões ou outros documentos expedidos por outro órgão ou entidade do Poder Executivo Federal, ressalvado o disposto no parágrafo único do art. 2º. (Vigência)

§ 1º O órgão ou entidade deverá, quando necessário, juntar aos autos do respectivo processo administrativo versão impressa da certidão ou documento obtido por meio eletrônico.

§ 2º As certidões ou outros documentos que contenham informações sigilosas do cidadão somente poderão ser obtidas por meio de sua autorização expressa.

§ 3º Quando não for possível a obtenção de atestados, certidões e documentos comprobatórios de regularidade de situação diretamente do órgão ou entidade expedidora, os fatos poderão ser comprovados mediante declaração escrita e assinada pelo cidadão, que, em caso de declaração falsa, ficará sujeito às sanções administrativas, civis e penais aplicáveis.

Art. 4º No âmbito da administração pública federal, os órgãos e entidades gestores de base de dados oficial colocarão à disposição dos órgãos e entidades públicos interessados as orientações para acesso às informações constantes dessas bases de dados, observadas as disposições legais aplicáveis e as diretrizes, orientações e procedimentos estabelecidos pelo Comitê Executivo do Governo Eletrônico, criado pelo Decreto de 18 de outubro de 2000.

Art. 5º No atendimento aos requerimentos do cidadão, os órgãos e entidades do Poder Executivo Federal observarão as seguintes práticas:

I - gratuidade dos atos necessários ao exercício da cidadania, nos termos da Lei nº 9.265, de 12 de fevereiro de 1996;

II - padronização de procedimentos referentes à utilização de formulários, guias e outros documentos; e

III - vedação de recusa de recebimento de requerimentos pelos serviços de protocolo, salvo quando o órgão ou entidade for manifestamente incompetente.

§ 1º Na ocorrência da hipótese referida no inciso III, os serviços de protocolo deverão prover as informações e orientações necessárias para que o cidadão possa dar andamento ao requerimento.

§ 2º Após a protocolização do requerimento, caso o agente público verifique que o órgão ou entidade é incompetente para o exame ou decisão da matéria, este deverá providenciar a remessa imediata do requerimento ao órgão ou entidade competente.

UNDP | E-governance an...

http://www3.undp.org/e-gov/gif2010/

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United Nations Development Programme

E-governance

Global GIF Meeting - Rio de Janeiro, Brazil 4 - 6 May 2010

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Background - Government Interoperabilty Frameworks - GIFs

Background

Although most developing countries have already established strategies to tackle key development targets, current trends indicate that no region will achieve the Millennium Development Goals (MDGs) by 2015. Some major advances in fact, particularly in the fight against poverty and hunger, are noted to have been slowed down or in some cases reversed due to the global economic crisis (MDG Indicators).

In most developing countries, the challenges are compounded by the widely-known fact that governments lack the capacity to deliver basic services (such as education and health) to its citizens. Even the capacity to provide information?a fundamental element in citizen-engagement and citizen-participation for democratic governance and pro-poor development? is hampered further by the recessions? impact on developing countries? limited domestic resources. As economic growth slows down or stalls and, as noted in the MDG Report 2009, aid flows from donor countries are reduced, governments of developing countries will need to be even more strategic in mobilizing and channeling limited resources.

These are opportune times for harnessing the potential of ICTs for development, particularly in helping governments to focus disparate departments towards common goals by, first of all, making sure that those departments are connected as one pipeline of key processes and services. It has been noted however that, although countries now have a national ICT for Development and/or e-government strategies in place, very few have been able to fully address the issues particularly of cost and scale (the ability to reach as many citizens as possible at the most affordable means available), as well as to fully and successfully address the core targets of their national development strategies.

To many local and national governments, e-government in particular has not yet proved to be the catalyst for improved efficiencies and more effective service delivery, for enhanced transparency and accountability, and for increased citizens? involvement in policy- and decision-making processes.

A quick scan of the applications and solutions deployed by governments across regions shows that access

LAW & REGULATION

- Dodd-Frank Act
- Public Comments
- Federal Register
- Enforcement Actions
- CFTC Staff Letters
- Dispositions
- Opinions & Adjudicatory Orders

Federal Register

- Open Comment Periods
- Proposed Rules
- Final Rules
- Sunshine Act Announcements
- Privacy Act Systems of Records Compilation

2010-30905

FR Doc 2010-30905[Federal Register: December 9, 2010 (Volume 75, Number 236)]

[Notices]

[Page 76706-76708]

From the Federal Register Online via GPO Access [wais.access.gpo.gov]

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COMMODITY FUTURES TRADING COMMISSION

SECURITIES AND EXCHANGE COMMISSION

[Release No. 34-63423; File No. 4-620]

Acceptance of Public Submissions on a Study Mandated by the Dodd-Frank Wall Street Reform and Consumer Protection Act, Section 719(b)

AGENCY: Commodity Futures Trading Commission; Securities and Exchange Commission.

ACTION: Request for Comments.

SUMMARY: The Dodd-Frank Wall Street Reform and Consumer Protection Act (``Dodd-Frank Act'') was enacted on July 21, 2010. The Dodd-Frank Act, among other things, mandates that the Commodity Futures Trading Commission (``CFTC'') and the Securities and Exchange Commission

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The Dodd-Frank Wall Street Reform and Consumer Protection Act (``Dodd-Frank Act'') was enacted on **July 21, 2010**. The Dodd-Frank Act, among other things, mandates that the Commodity Futures Trading Commission (``CFTC'') and the Securities and Exchange Commission (``SEC'') conduct a study on ``**the feasibility of requiring the derivatives industry to adopt standardized computer-readable algorithmic descriptions which may be used to describe complex and standardized financial derivatives.**'' **These algorithmic descriptions should be designed to ``facilitate computerized analysis of individual derivative contracts and to calculate net exposures to complex derivatives**.'' The study also must consider the extent to which the algorithmic description, ``**together with standardized and extensible legal definitions, may serve as the binding legal definition of derivative contracts**.''

7. Do you rely on a discrete set of computer-readable descriptions (``**ontologies**'') to define and describe derivatives transactions and positions? If yes, what computer language do you use?

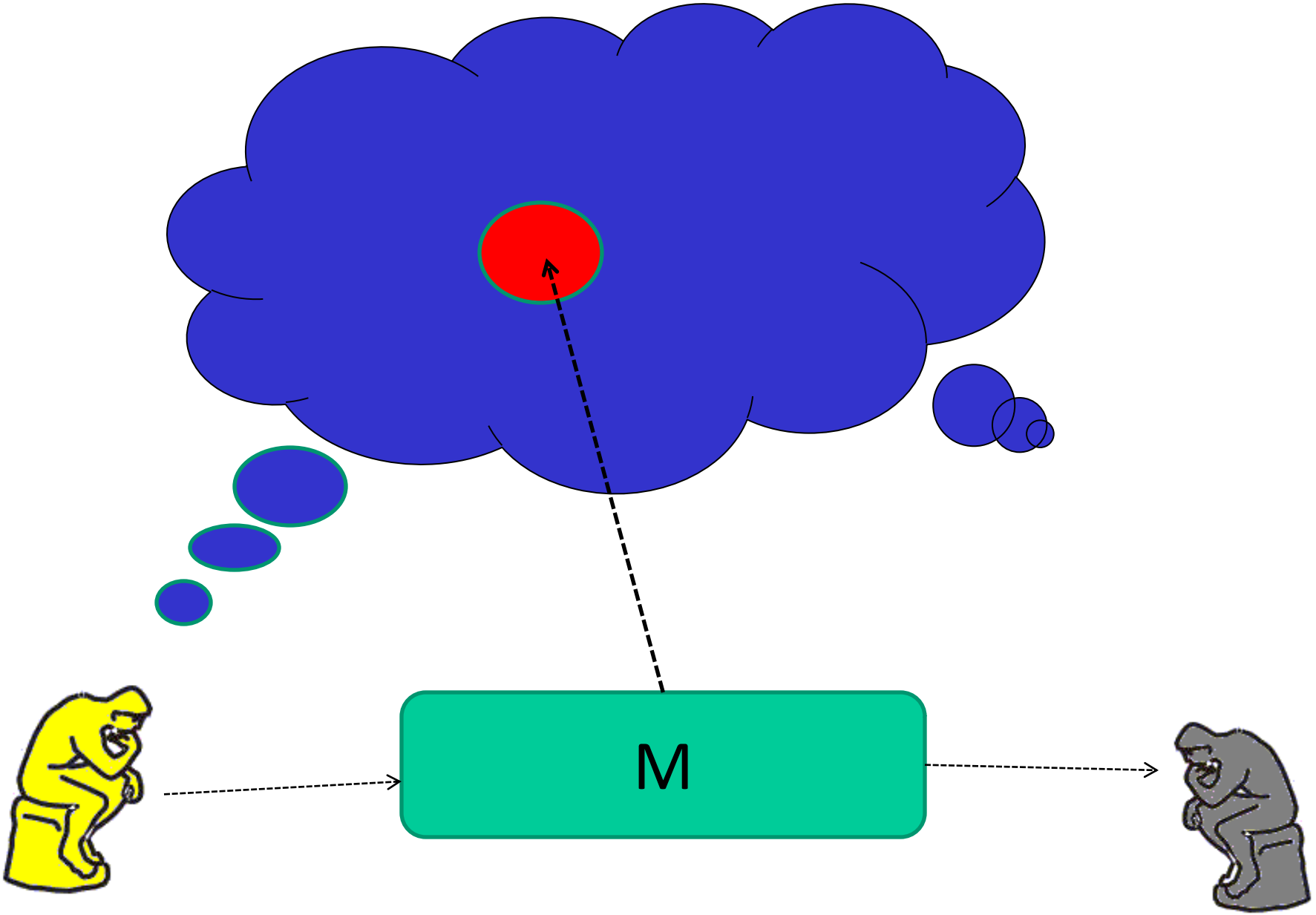
8. If you use one or more **ontologies** to define derivatives transactions and positions, are they proprietary or open to the public? Are they used by your counterparties and others in the derivatives industry?

9. How do you maintain and extend the **ontologies** that you use to define derivatives data to cover new financial derivative products? How frequently are new terms, concepts and definitions added?

10. What is the scope and variety of derivatives and their positions covered by the **ontologies** that you use? What do they describe well, and what are their limitations?

.

What is common to all these cases?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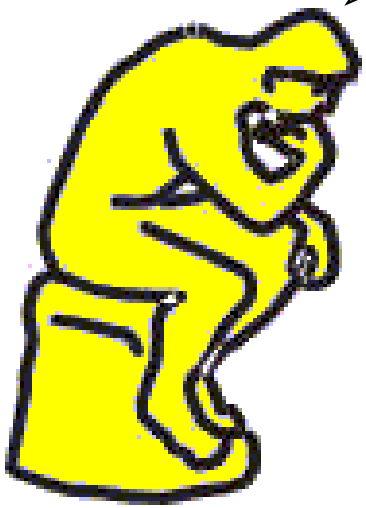

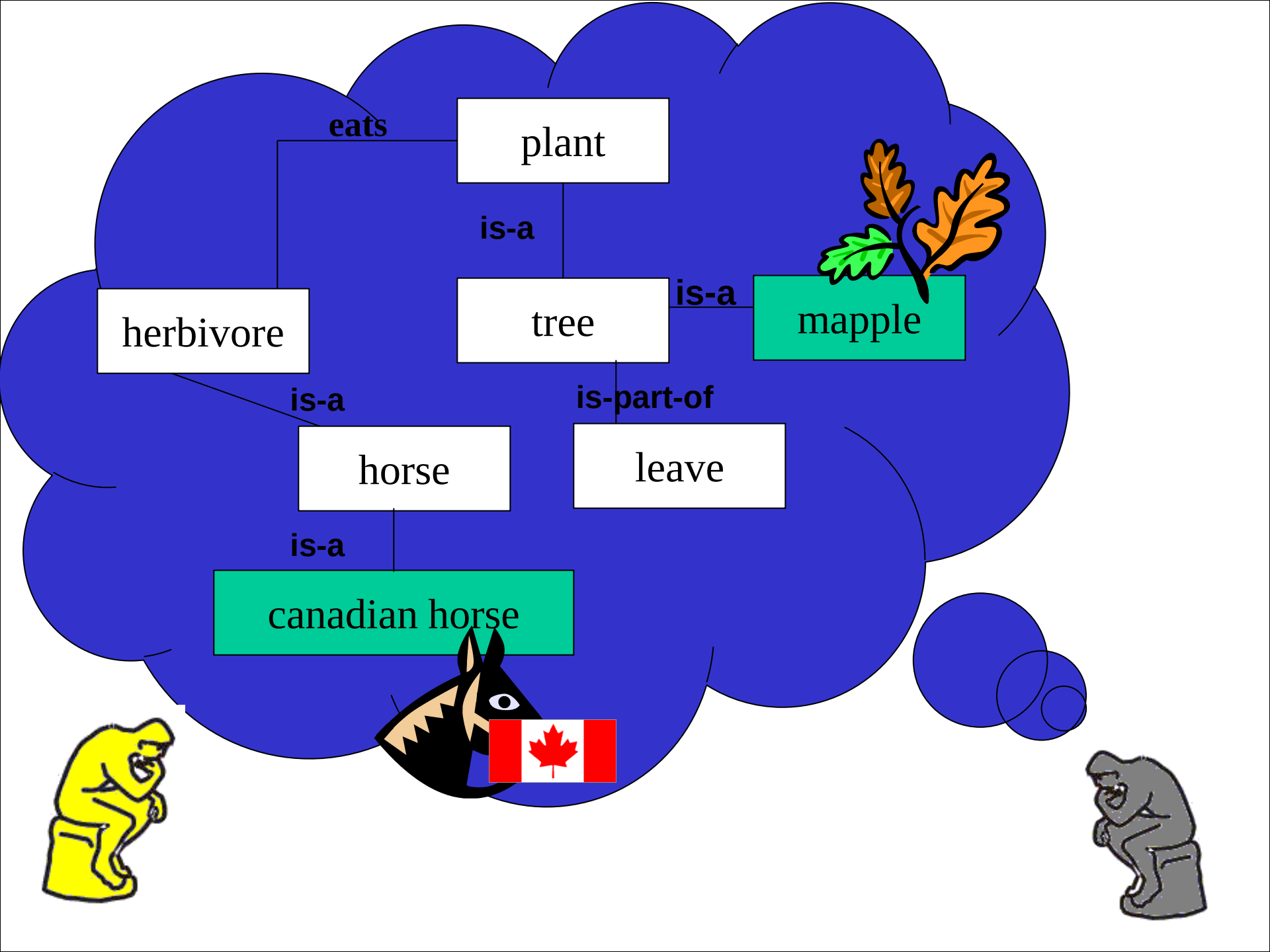
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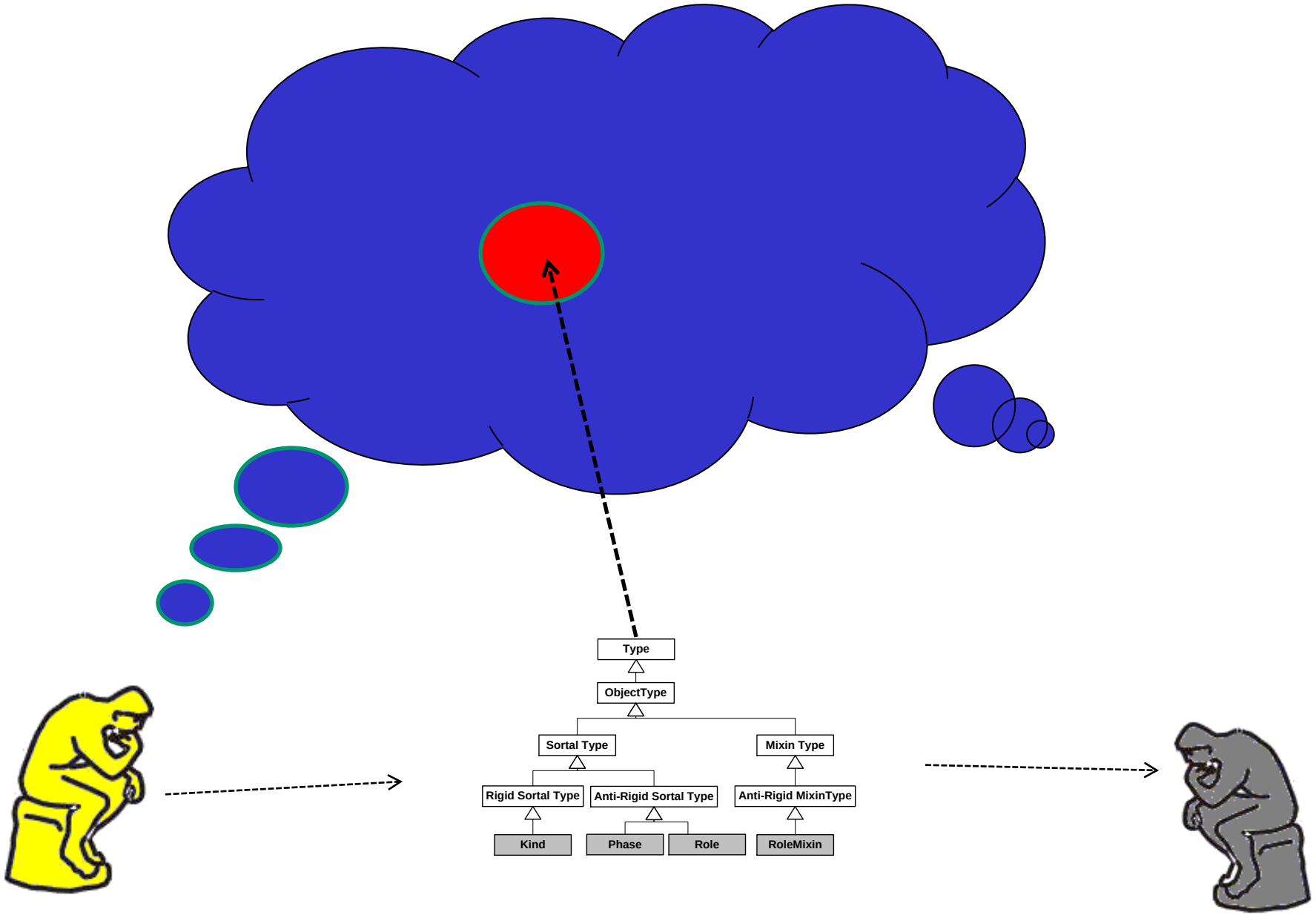
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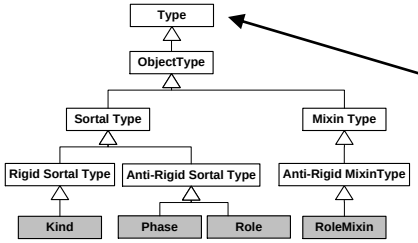
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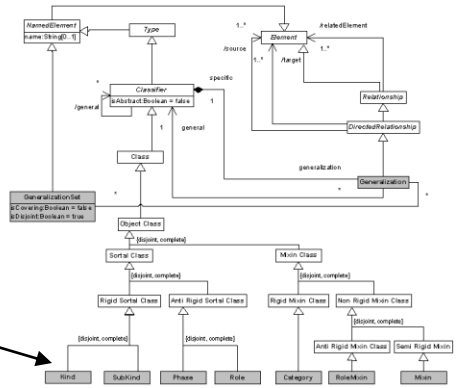
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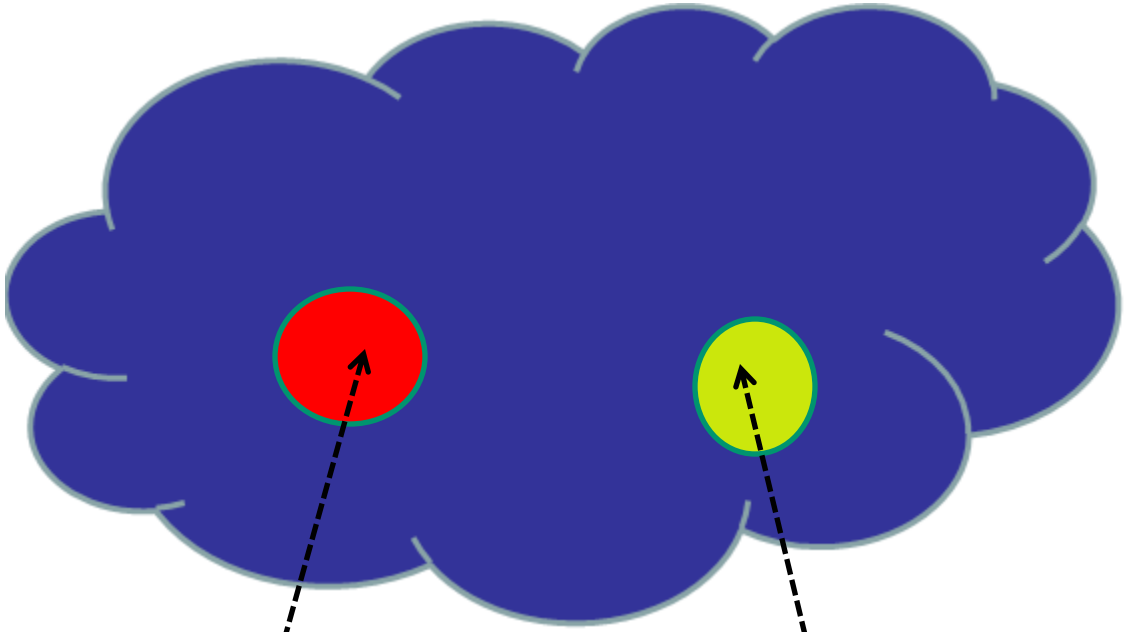

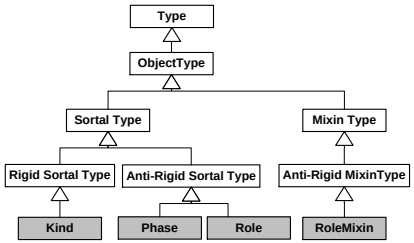
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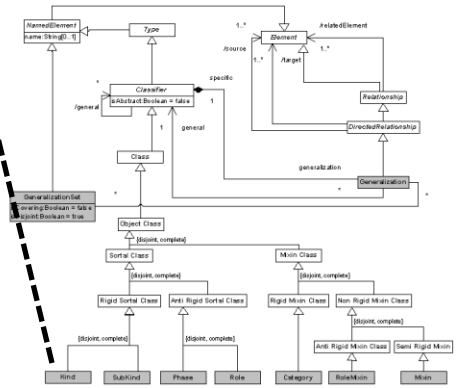

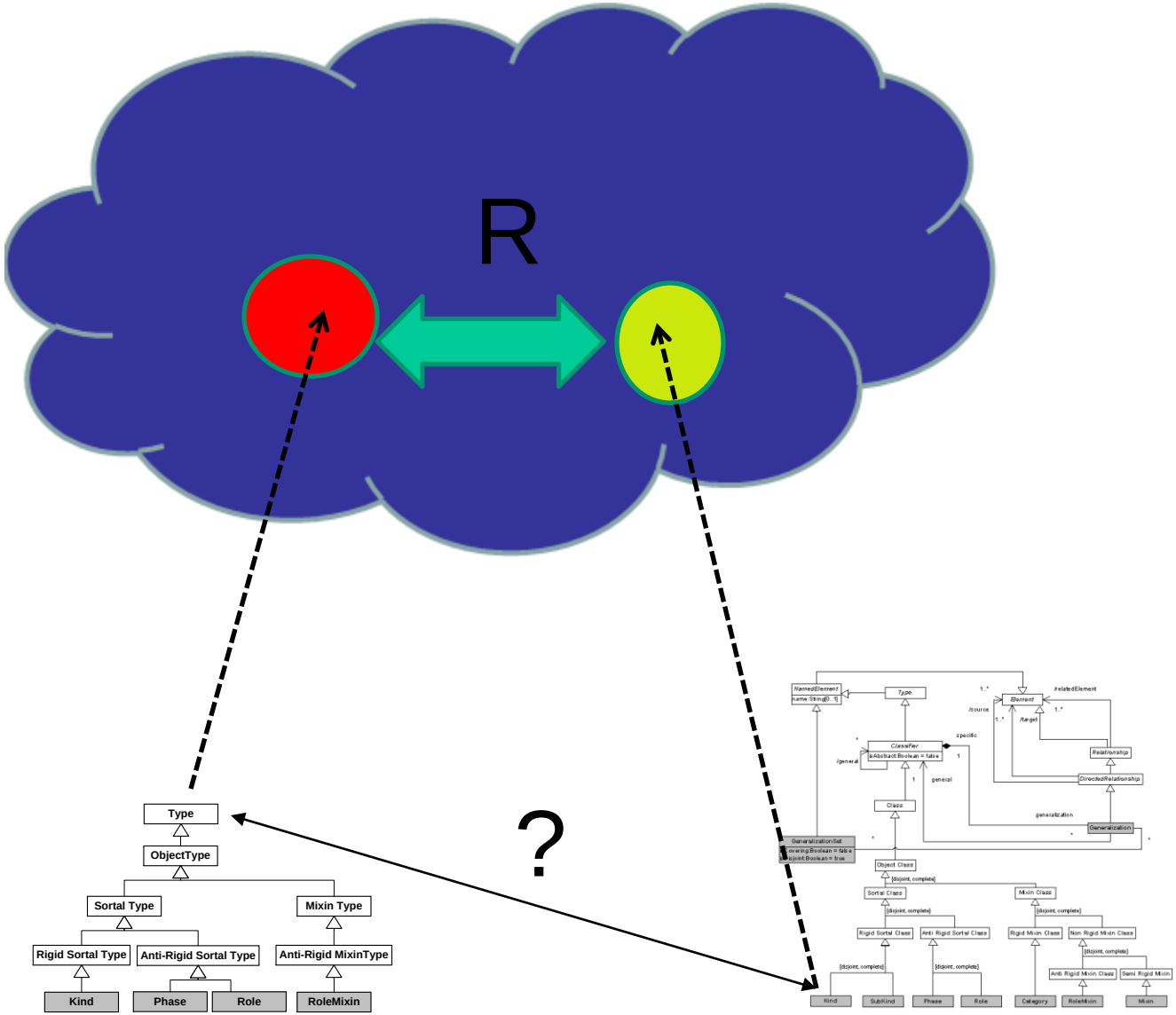
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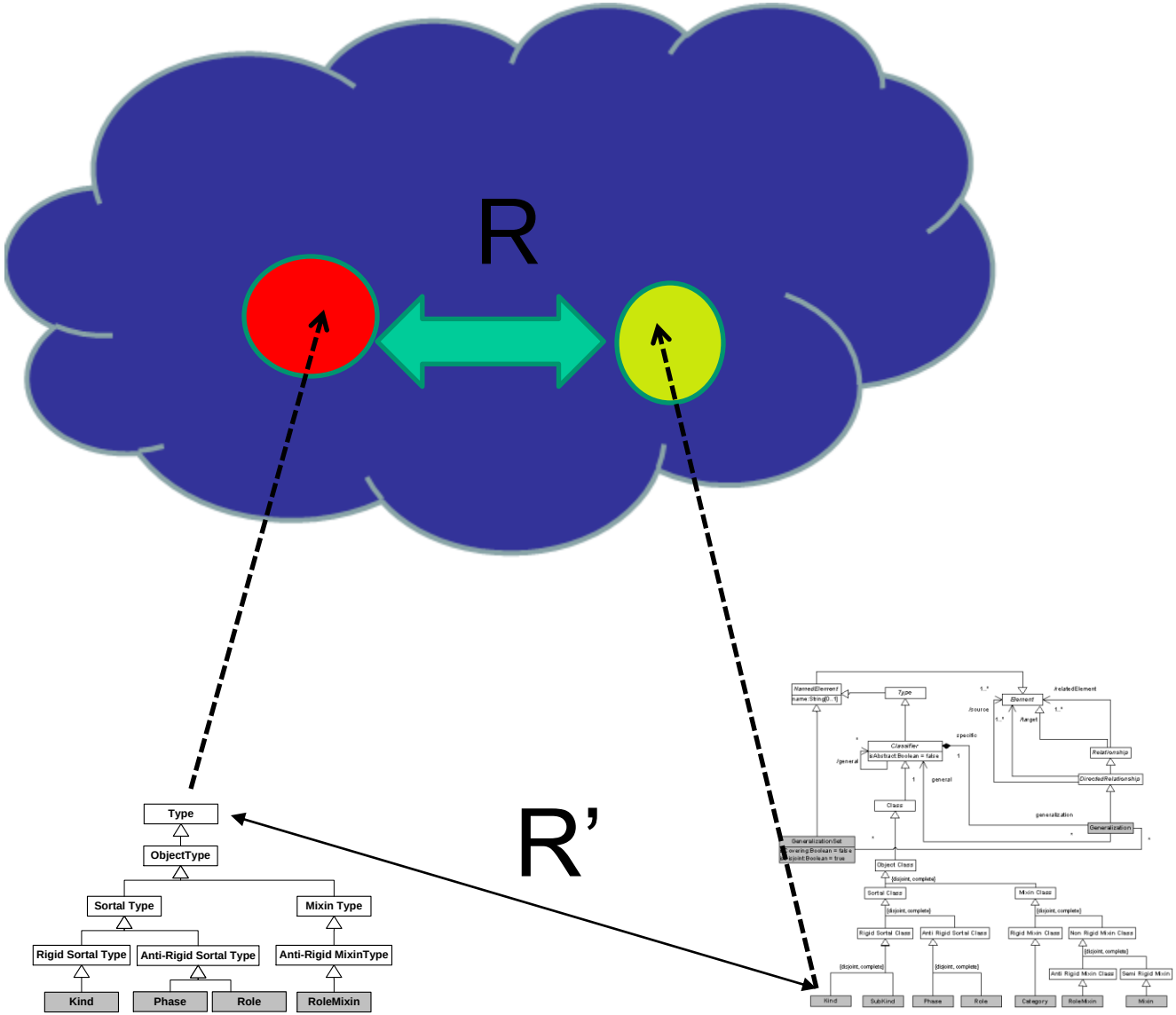
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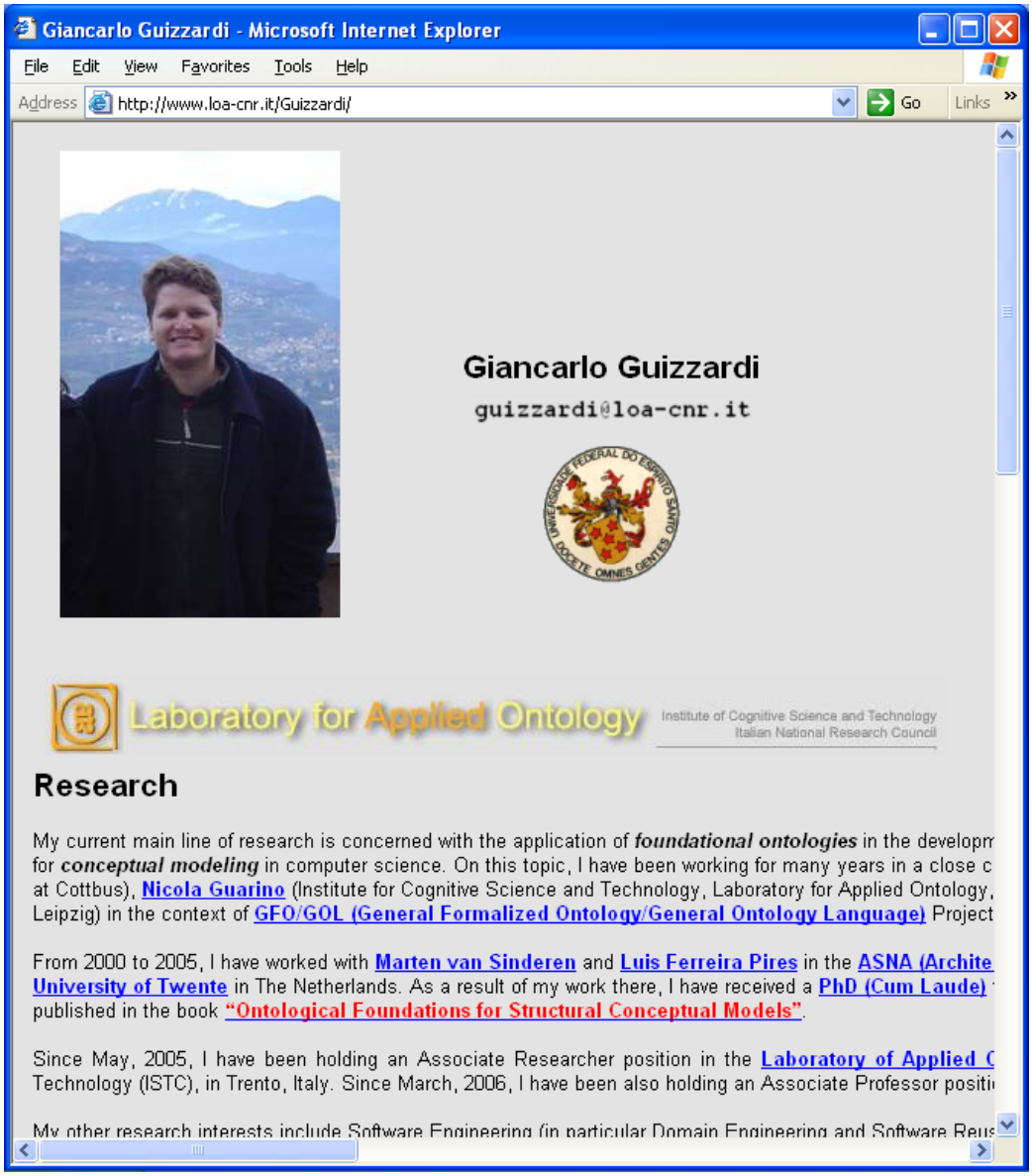
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Laboratory for Applied Ontology
Institute of Cognitive Science and Technology
Italian National Research Council
Research
My current main line of research is concerned with the application of foundational ontologies in the developm
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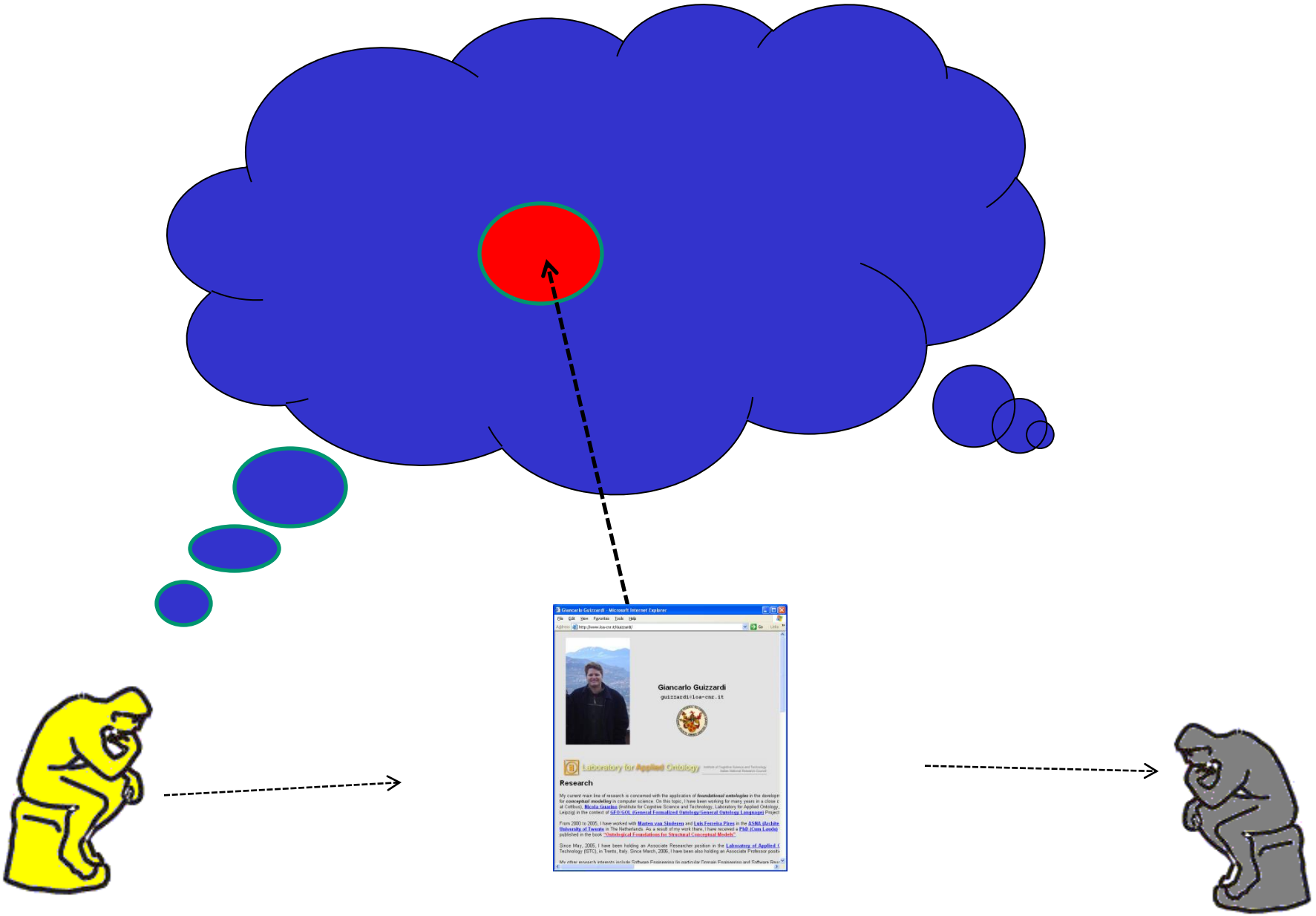
My other research interests include Software Engineering (in particular Domain Engineering and Software Reus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Laboratory for Applied Ontology
Research

What we see…

Giancarlo Guizzardi
Research

My current main line of research is concerned with the application of foundational ontologies in the development of philosophically and cognitively well-justified methodological tools for conceptual modeling in computer science. On this topic, I have been working for many years in a close collaboration with Gerd Wagner (Brandenburg University of Technology at Cottbus), Nicola Guarino (Institute for Cognitive Science and Technology, Laboratory for Applied Ontology, Trento), and Heinrich Herre (Formal Concepts Group, University of Leipzig) in the context of GFO/GOL (General Formalized Ontology/General Ontology Language) Project.

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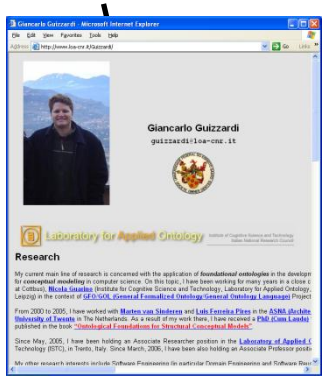
My other research interests include Software Engineering (in particular Domain Engineering, Semantic Application and Interoperability of Tools, Semantic Software Environments, Software Reuse), FOL and Modal Logics, Design of Domain-specific visual languages, Formal Languages and Design Methods and Architectures for Open Distributed Systems (including Enterprise modeling, Distributed Multimedia Systems and Context-Aware applications).

To know more about my research one should check my Publications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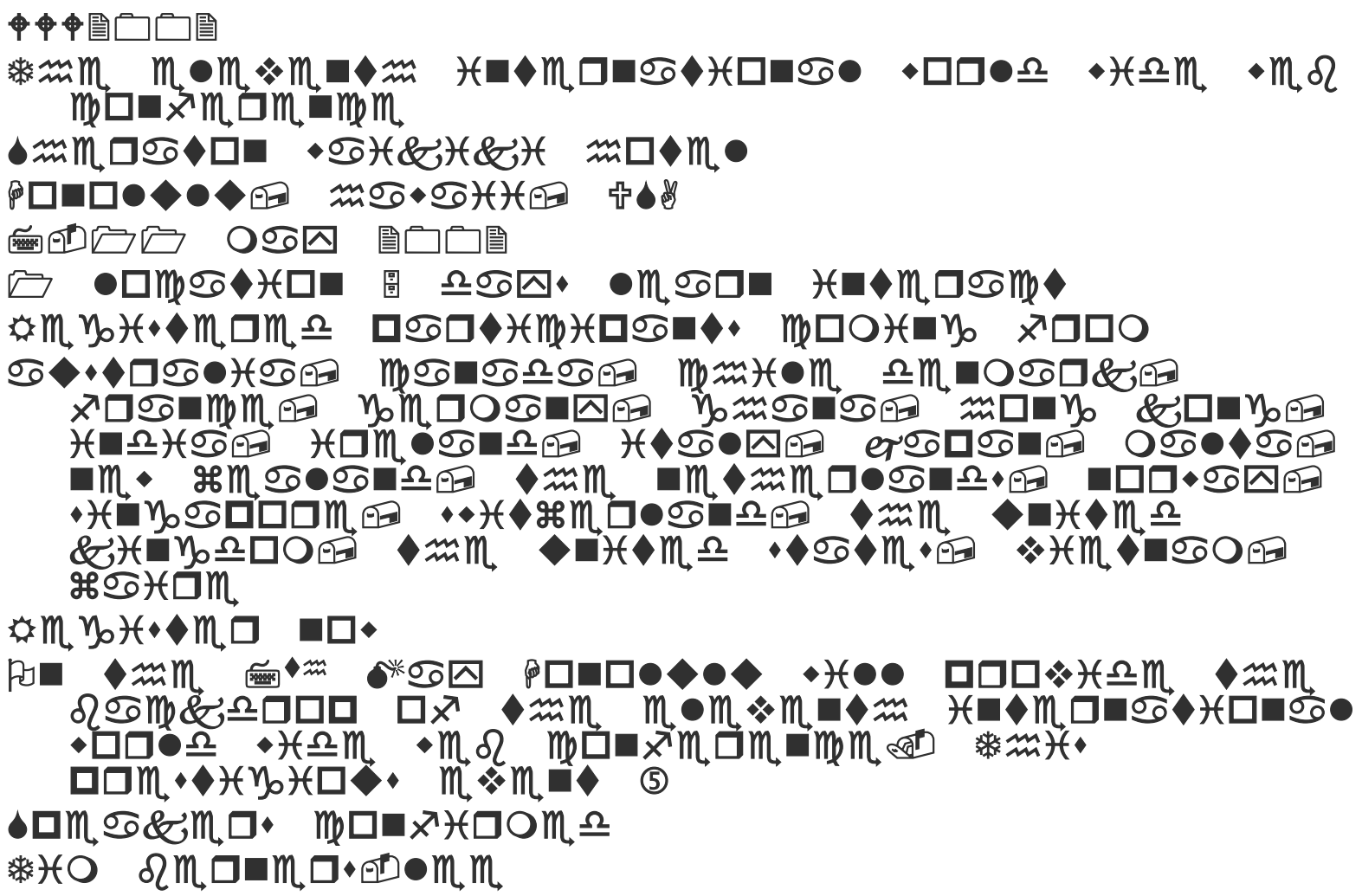
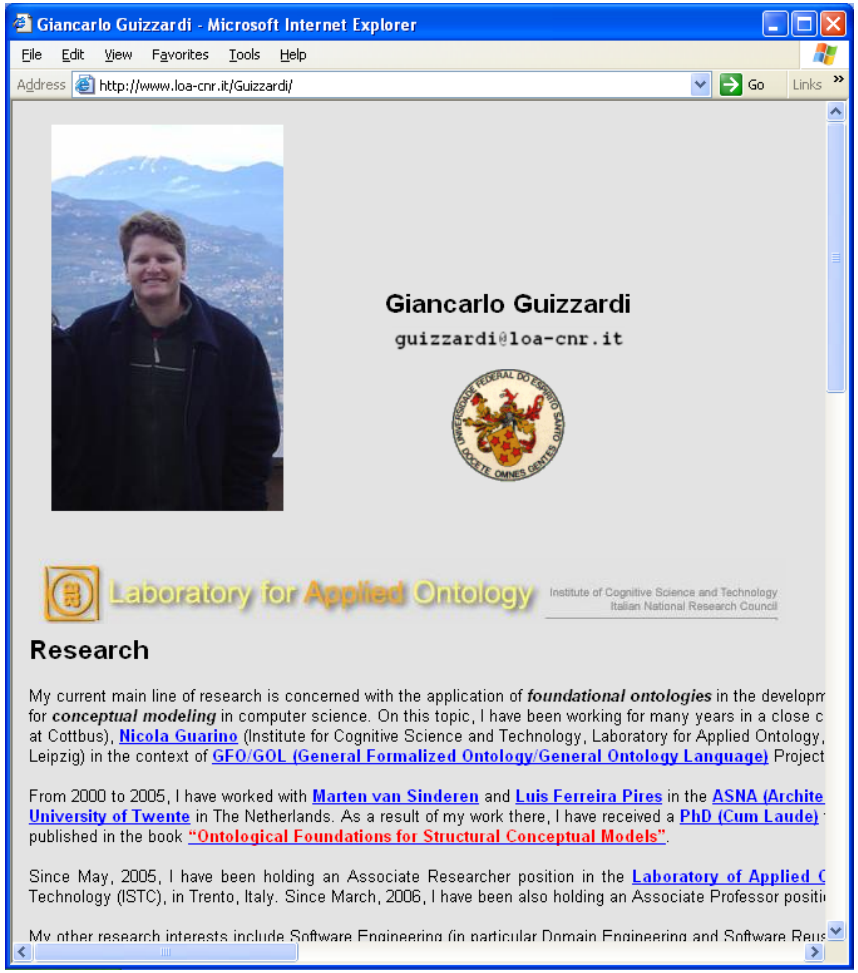
Giancarlo Guizzardi
guizzardi@loa-cnr.it
Laboratory for Applied Ontology
Research

What our computer sees…

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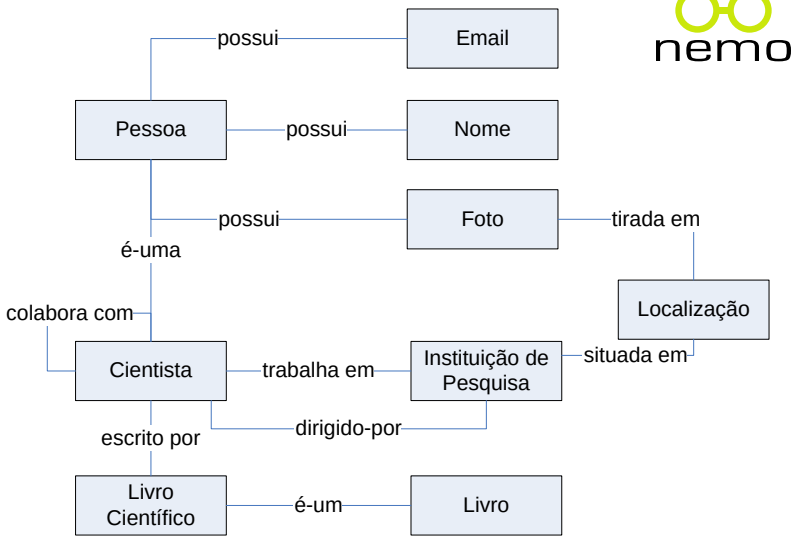
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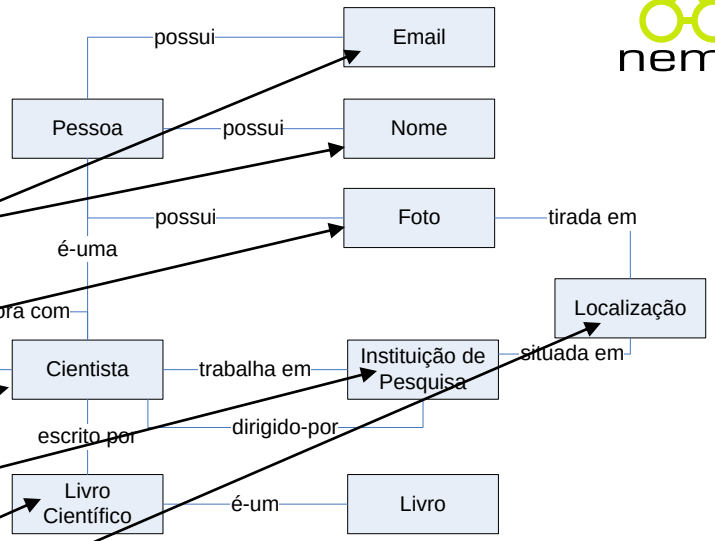
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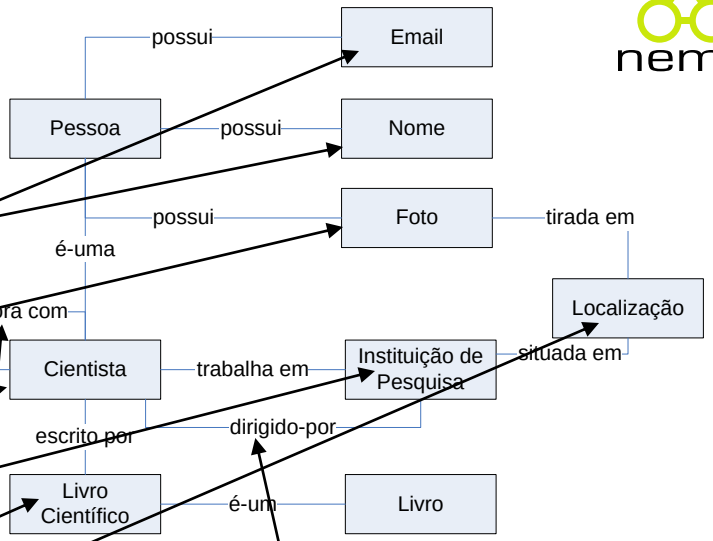
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Nicola Guarino
Trento
+39 0461 828486
Email
Nicola Guarino is the group leader of LOA. He graduated in electrical engineering at the University of Padova in 1978. Since 1991, he has been playing a leading role in promoting the study of ontological foundations of knowledge engineering and conceptual modeling. He is general chair of the Formal Ontology in Information Systems (FOIS) conference series, and associate editor of the International Journal of Human-Computer Studies. He was also guest editor of several journal special issues related to formal ontology and information systems.


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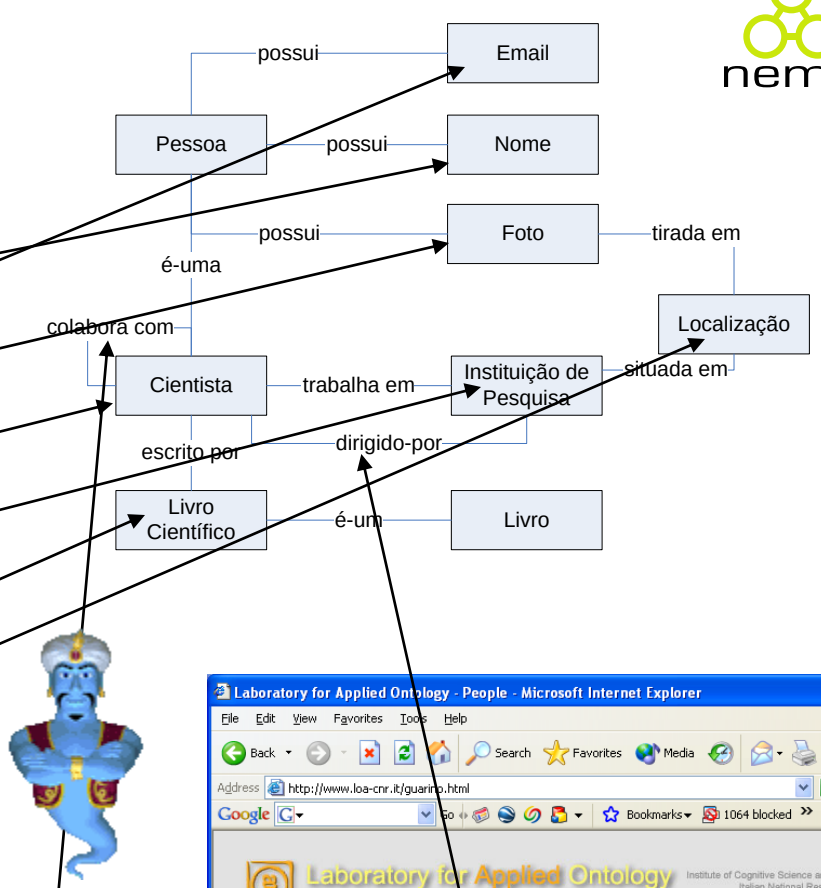
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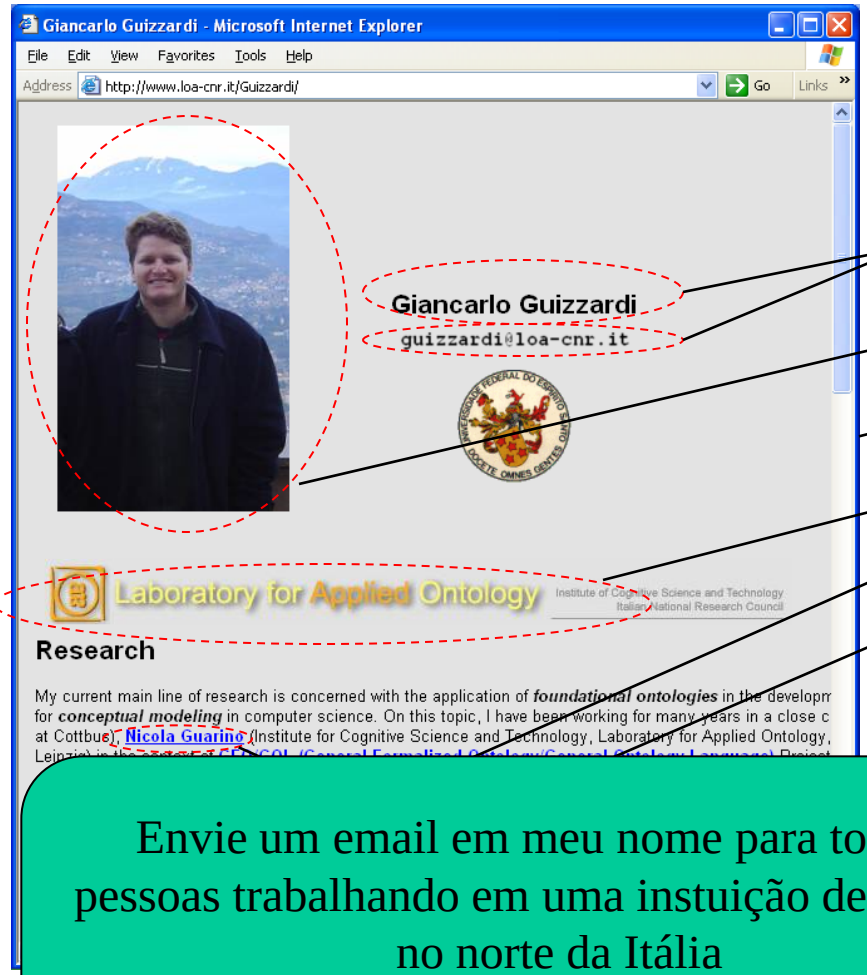
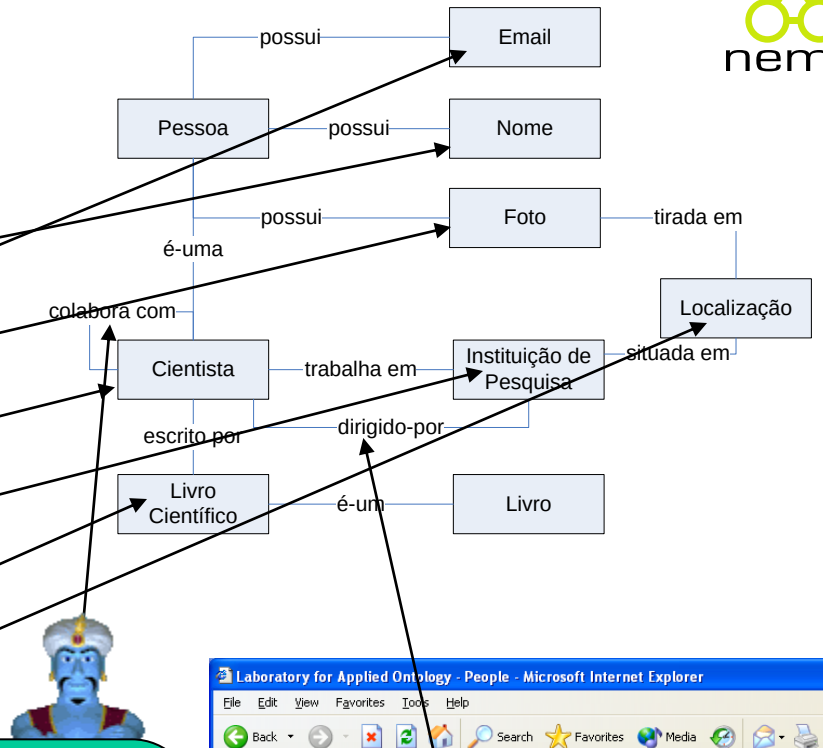
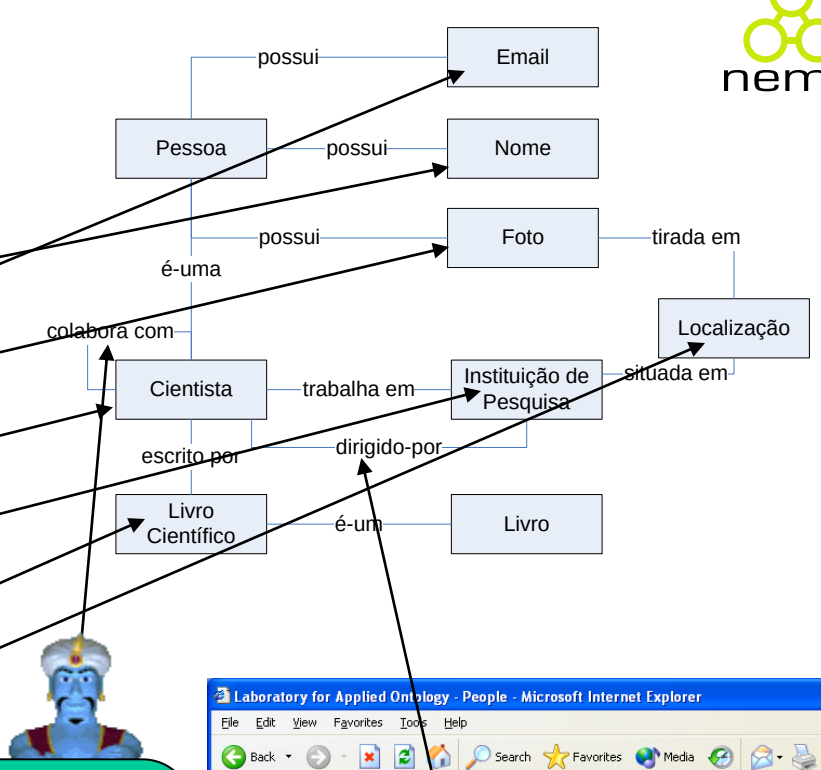




Envie um email em meu nome para todas as pessoas trabalhando em uma instuição de pesquisa no norte da Itália



Compre todos os livros escritos por cientistas que colaboram com o diretor do LOA

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<owl:Class rdf:ID="animal">
   <rdfs:comment>Animals form a class</rdfs:comment>
</owl:Class>

<owl:Class rdf:ID="plant">
   <rdfs:comment>
   Plants form a class disjoint from animals
   </rdfs:comment>
   <owl:disjointWith="#animal"/>
</owl:Class>

<owl:Class rdf:ID="tree">
   <rdfs:comment>Trees are a type of plants</rdfs:comment>
   <rdfs:subClassOf rdf:resource="#plant"/>
</owl:Class>

<owl:Class rdf:ID="branch">
   <rdfs:comment>Branches are parts of trees </rdfs:comment>
   <rdfs:subClassOf>
      <owl:Restriction>
         <owl:onProperty rdf:resource="#is-part-of"/>
         <ow:allValuesFrom rdf:resource="#tree"/>
      </owl:Restriction>
   </rdfs:subClassOf>
</owl:Class>
```

```
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   <rdfs:subClassOf>
      <owl:Restriction>
         <owl:onProperty rdf:resource="#is-part-of"/>
         <owl:allValuesFrom rdf:resource="#branch"/>
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<owl:ObjectProperty rdf:ID="eats">
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</owl:ObjectProperty>
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        that eat also animals</rdfs:comment>
    <owl:intersectionOf rdf:parsetype="Collection">
        <owl:Class rdf:about="#animal"/>
        <owl:Restriction>
            <owl:onProperty rdf:resource="#eats"/>
            <owl:someValuesFrom rdf:resource="#animal"/>
        </owl:Restriction>
    </owl:intersectionOf>
</owl:Class>
```

```
<owl:Class rdf:ID="herbivore">
  <rdfs:comment>
  Herbivores are exactly those animals that eat only plants,
     or parts of plants
  </rdfs:comment>
  <owl:intersectionOf rdf:parsetype="Collection">
     <owl:Class rdf:about="#animal"/>
     <owl:Restriction>
        <owl:onProperty rdf:resource="#eats"/>
        <owl:allValuesFrom>
           <owl:unionOf rdf:parsetype="Collection">
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              <owl:Restriction>
                 <owl:onProperty rdf:resource="#is-part-of"/>
                 <owl:allValuesFrom rdf:resource="#plant"/>
              </owl:Restriction>
           </owl:unionOf>
        </owl:allValuesFrom>
     </owl:Restriction>
  </owl:intersectionOf>
</owl:Class>
```

What we can do

Define Classes

Define relations between classes

Define classes using set-theoretical operators

Define datatypes and datatype properties

Define (binary, directed) domain relations

Define relations between relations

Define formal meta-properties of relations

Important Limitations and Unanswered Questions

Do all classes relate to their instances in the same manner?

Where do the formal meta-properties of relations come from?

In particular, how do I delimit the scope of transitivity of part-whole relations?

Where relations have to be binary?

How can we capture temporal notions?

Reasoning Rules

$A \rightarrow B$

A

B

$A \vee B$

$\neg A$

B

Classical Logics (Predicate Calculus)

FOR ALL x Scientist(x) $\rightarrow$ Person (x)

FOR ALL x ScientificBook(x) $\rightarrow$ Book (x) AND (EXISTS y Scientist(y) AND AuthorOf(y,x))

FOR ALL x,y ScientificBook(x) AND AuthorOf(y,x) $\rightarrow$ Scientist(y)

Let´s assume the following facts:

ScientificBook(Data&Reality)

AuthorOf(Data&Reality,Bill Kent)

Can we prove that Bill Kent is a person?

Classical Logics (Predicate Calculus)

YES!

FOR ALL x,y ScientificBook(x) AND AuthorOf(y,x) $\rightarrow$ Scientist(y)

ScientificBook(Data&Reality)

AuthorOf(Data&Reality,Bill Kent)

Scientist(BillKent)

FOR ALL x Scientist(x) $\rightarrow$ Person (x)

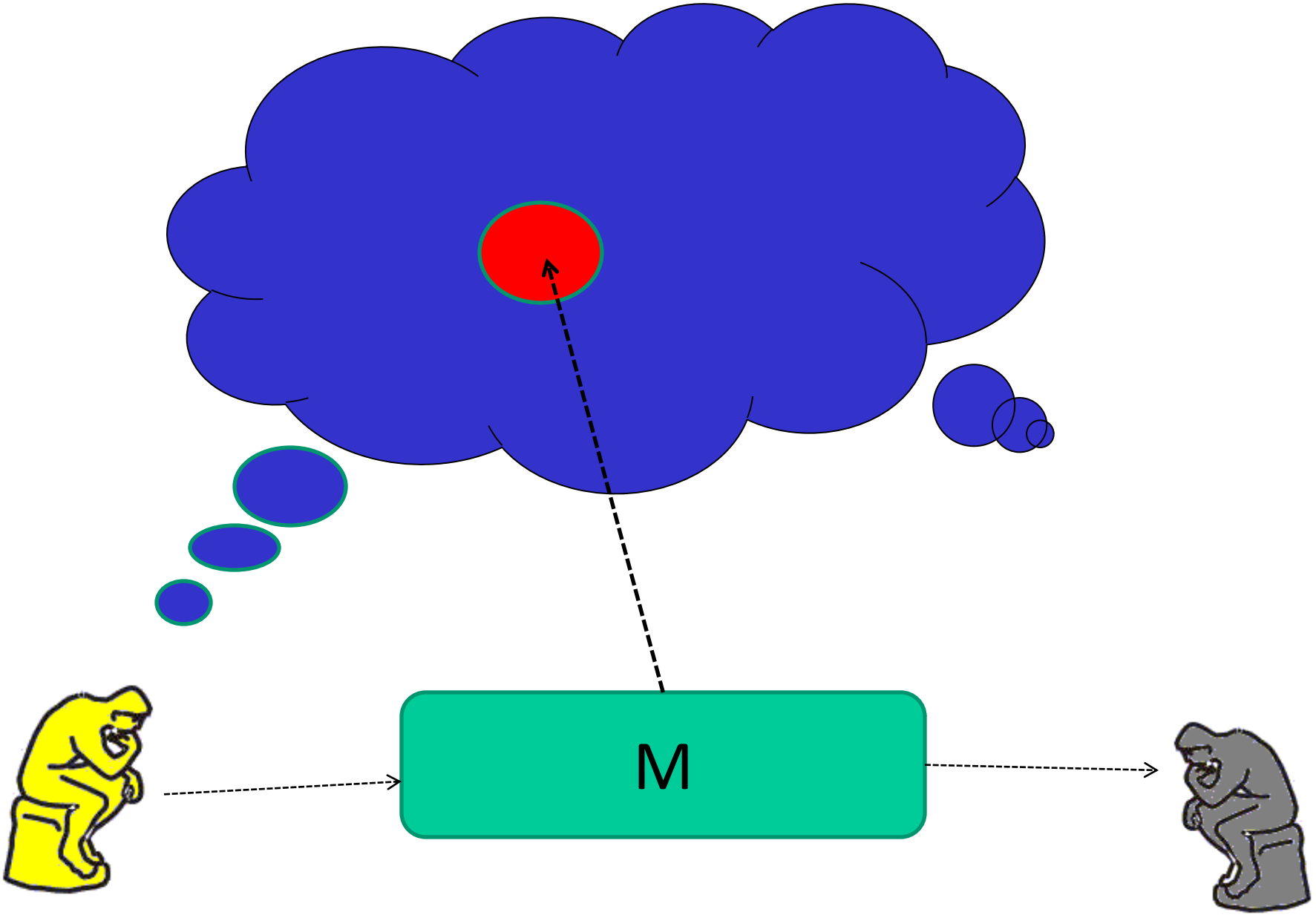
Scientist(BillKent)

Person(BillKent)

Relevant Reference

Antoniou, G. ; van Harmelen, F., "Web Ontology Language: OWL", Handbook on Ontologies in Information Systems", Springer-Verlag, 2003.

SEMANTIC INTEROPERABILITY: THE PROBLEM REVISITED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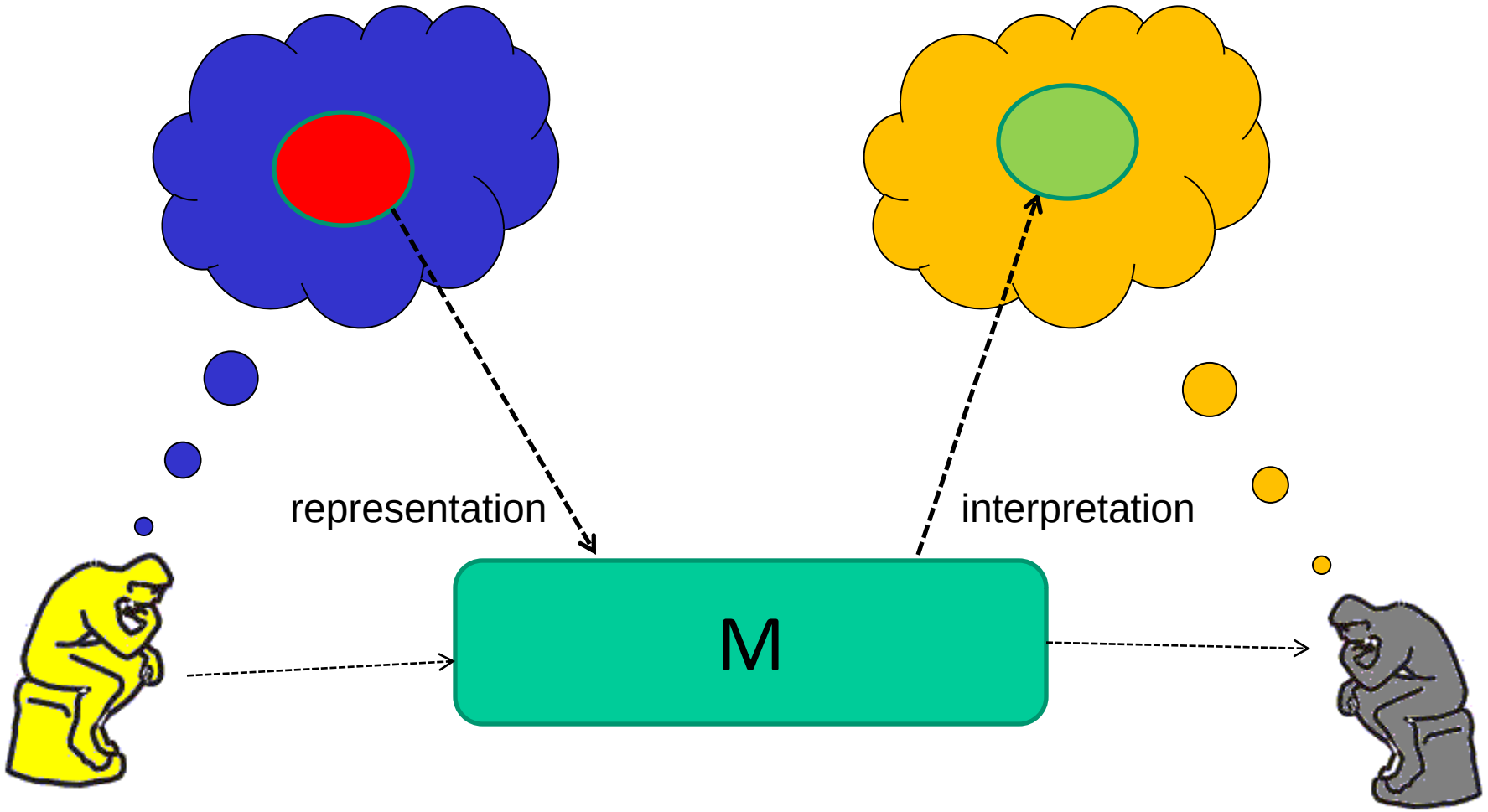
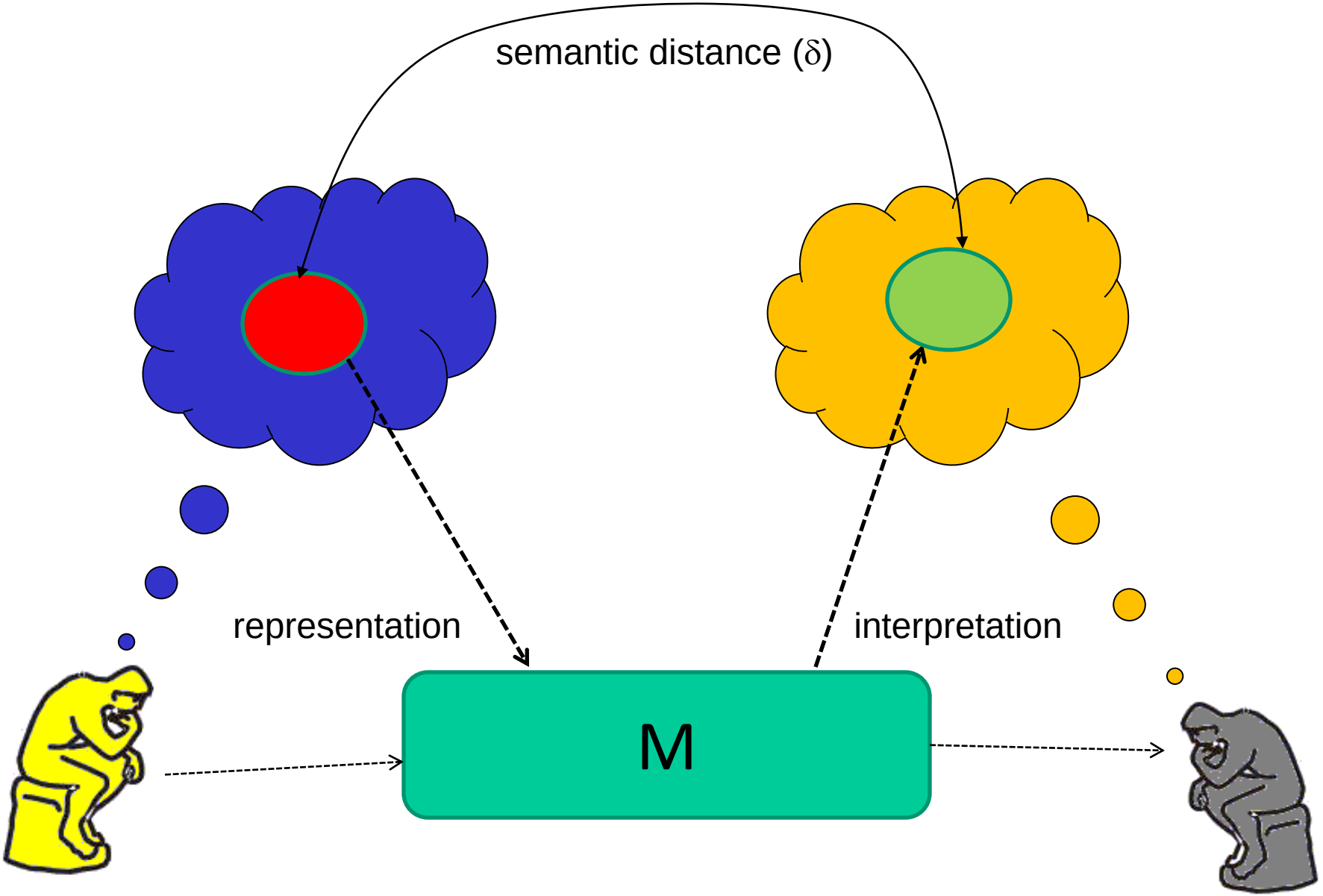

representation
interpretation
M


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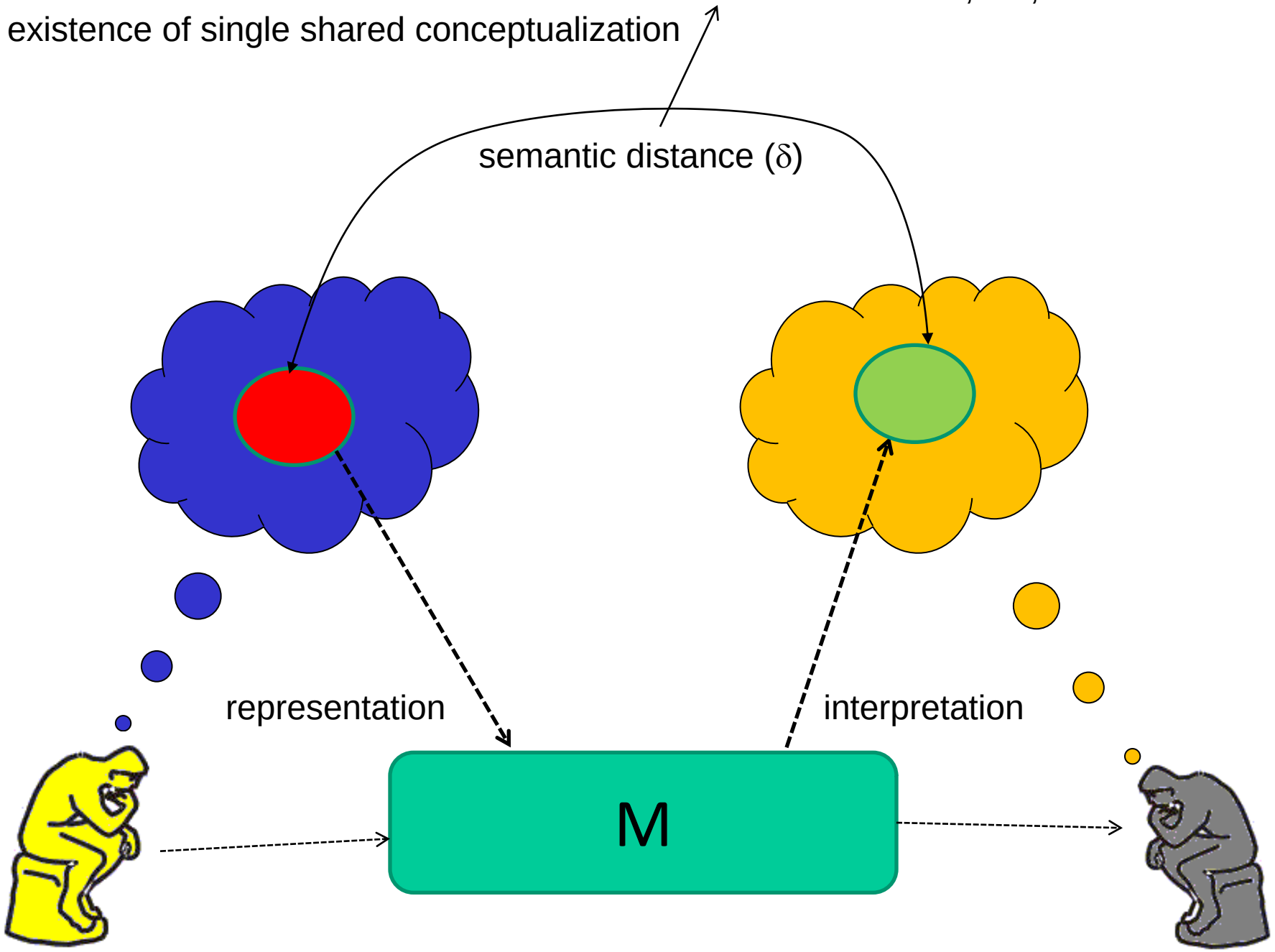
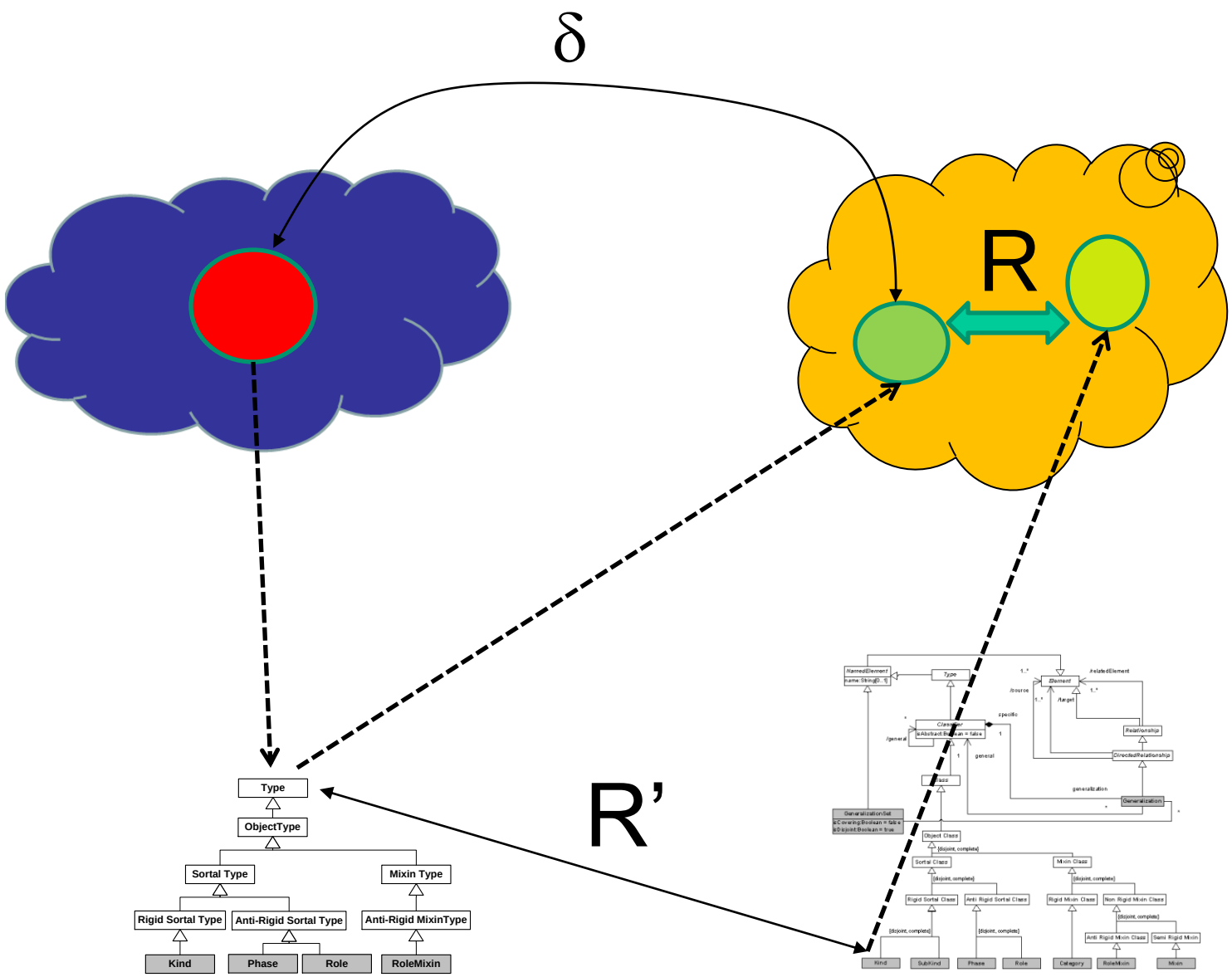
when $\delta < x$ then we consider the communication to be effective, i.e., we assume the existence of single shared conceptualization

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Anti-Rigid Sortal Type
Anti-Rigid MixinType
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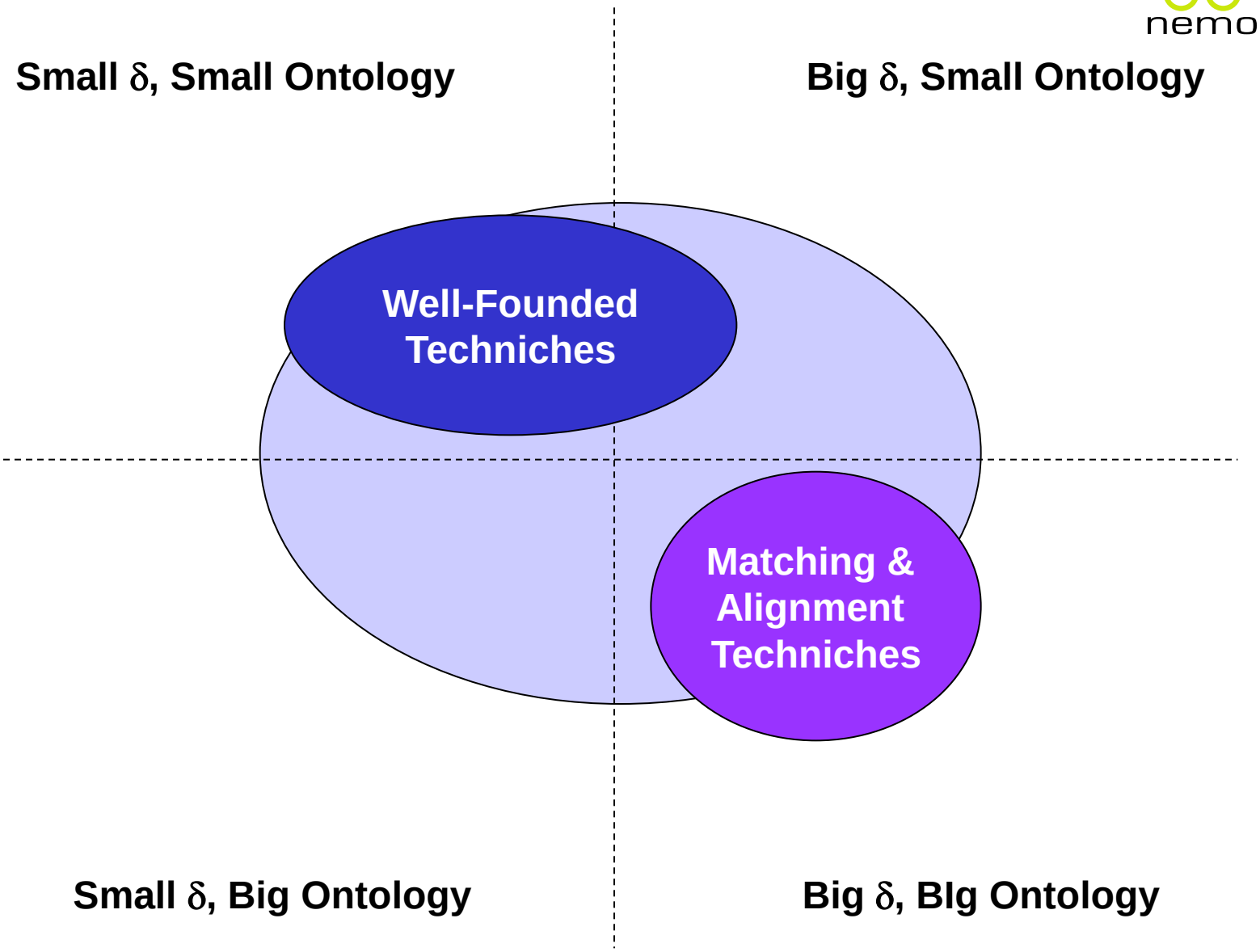
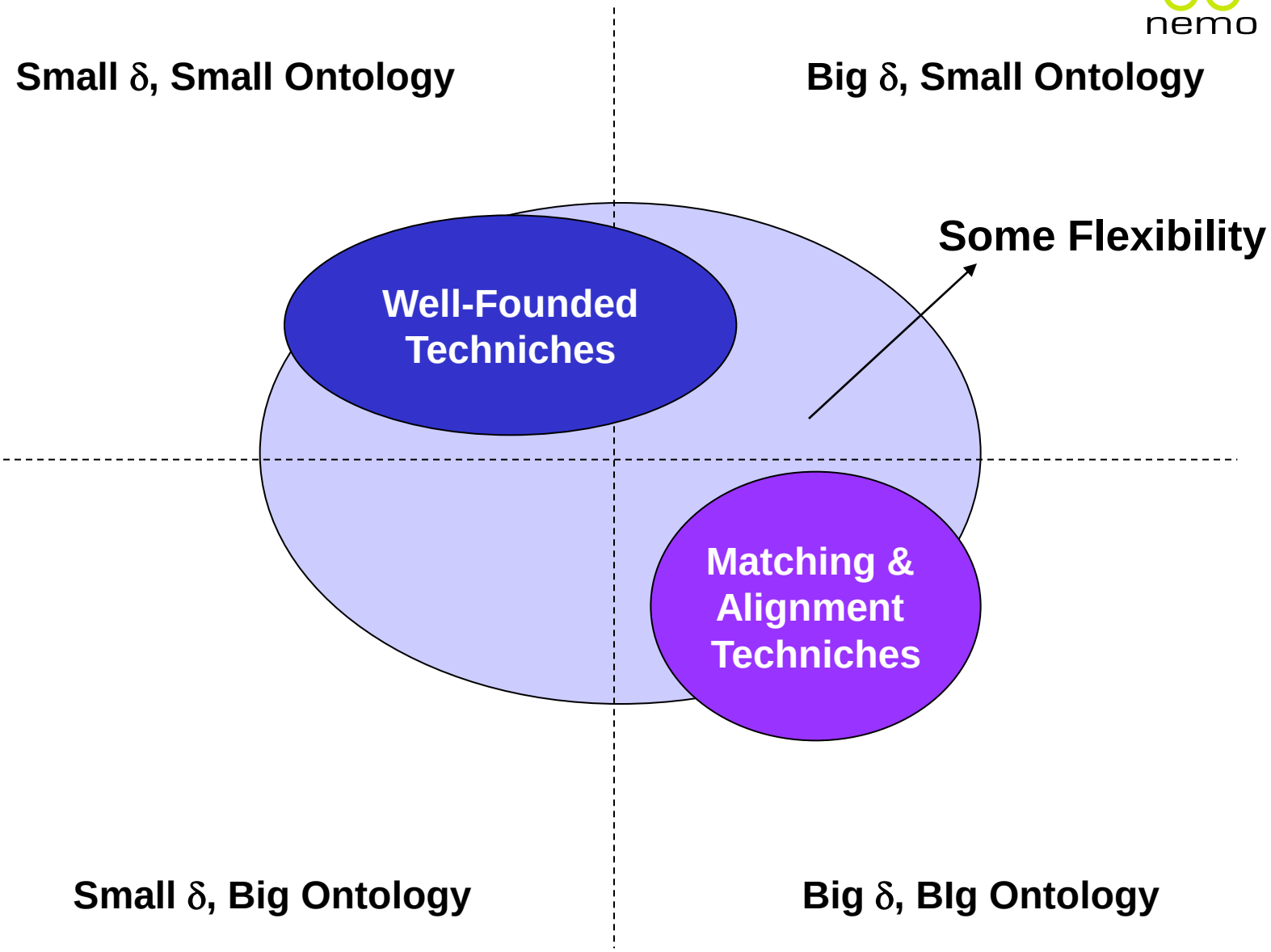
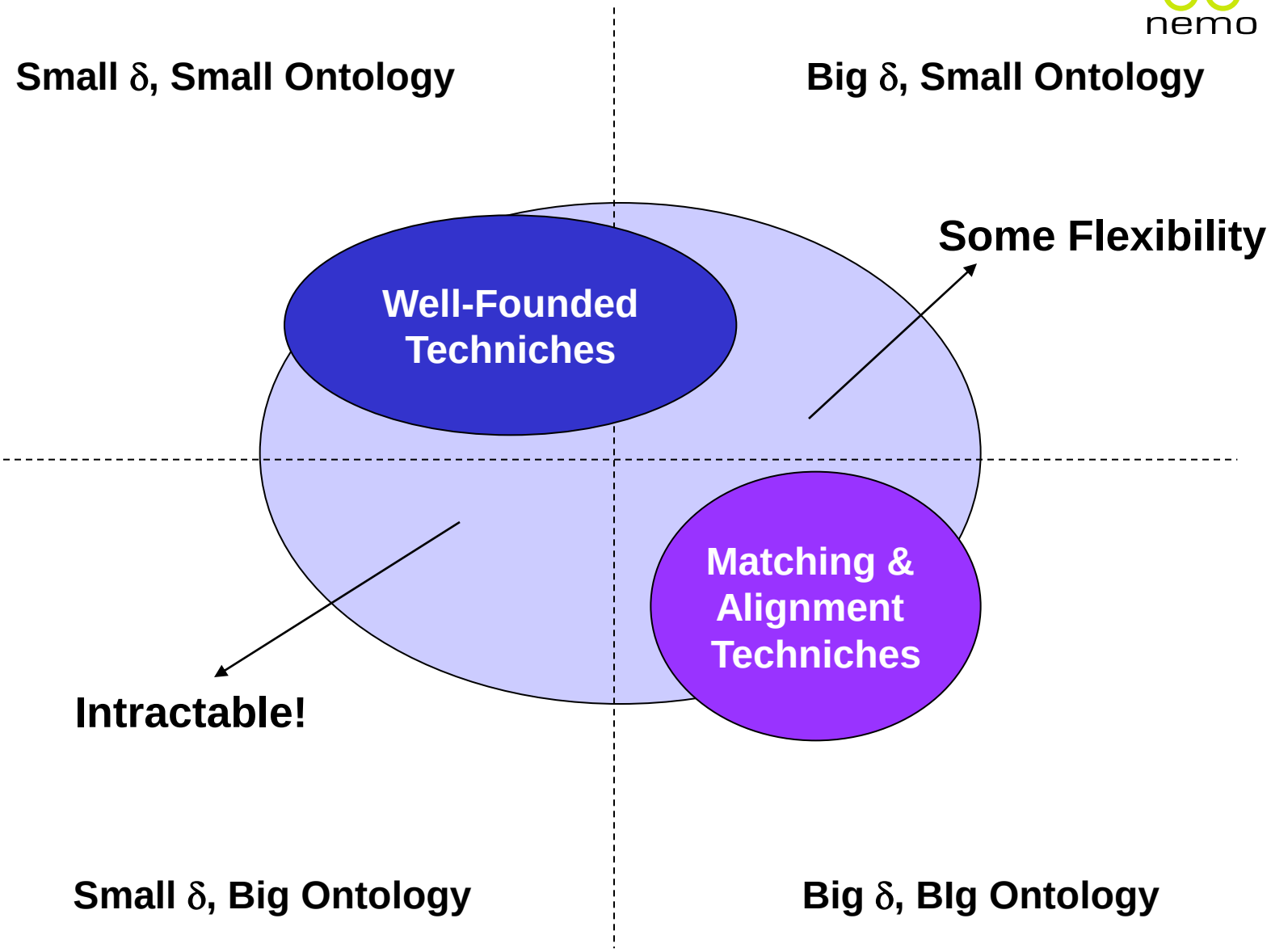
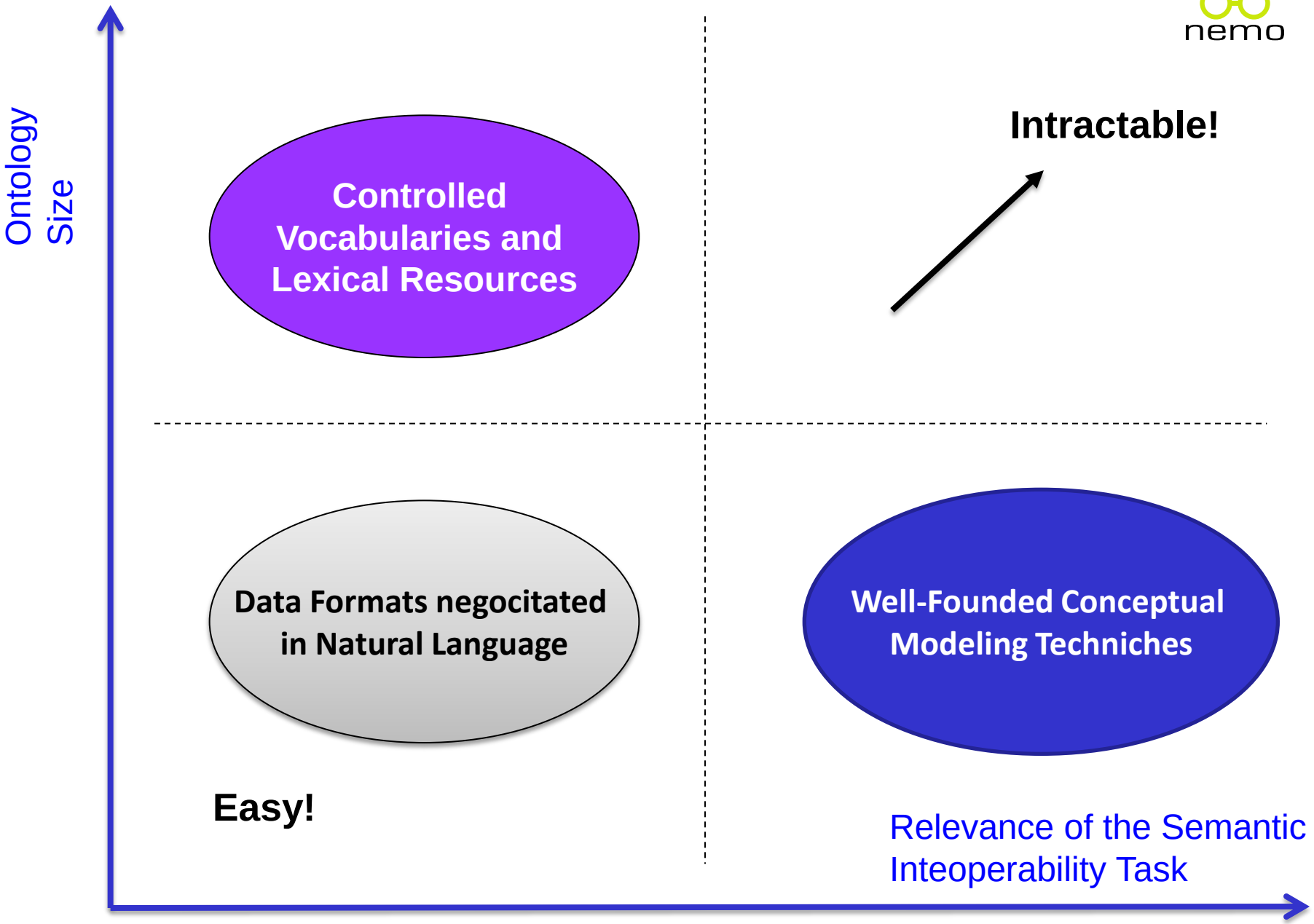
Phase
Role
RoleMixin


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

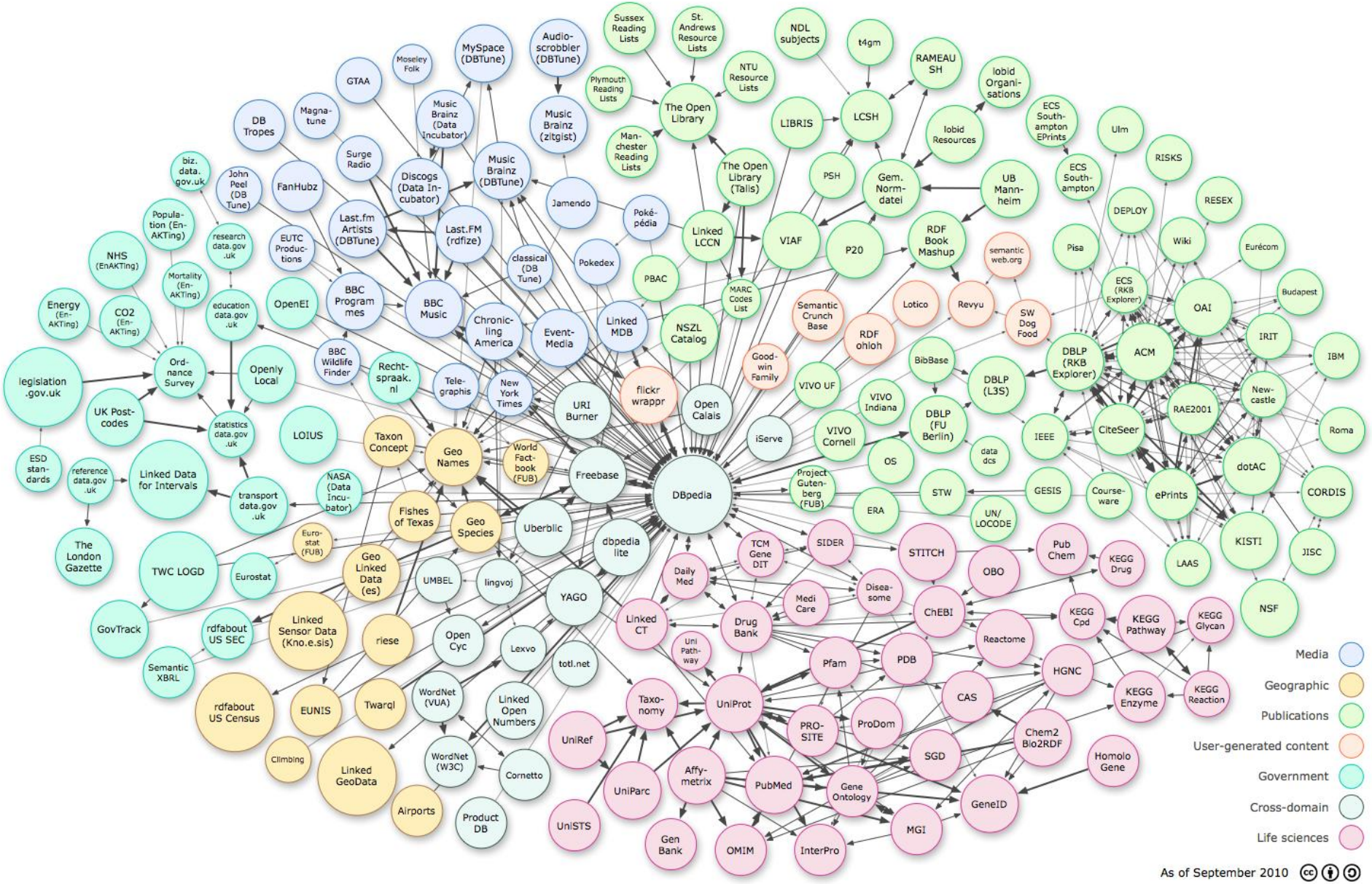

Small δ, Small Ontology
Big δ, Small Ontology
Some Flexibility
Well-Founded Techniches
Matching & Alignment Techniches
Small δ, Big Ontology
Big δ, Blg Ontology


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

An Alternative View…

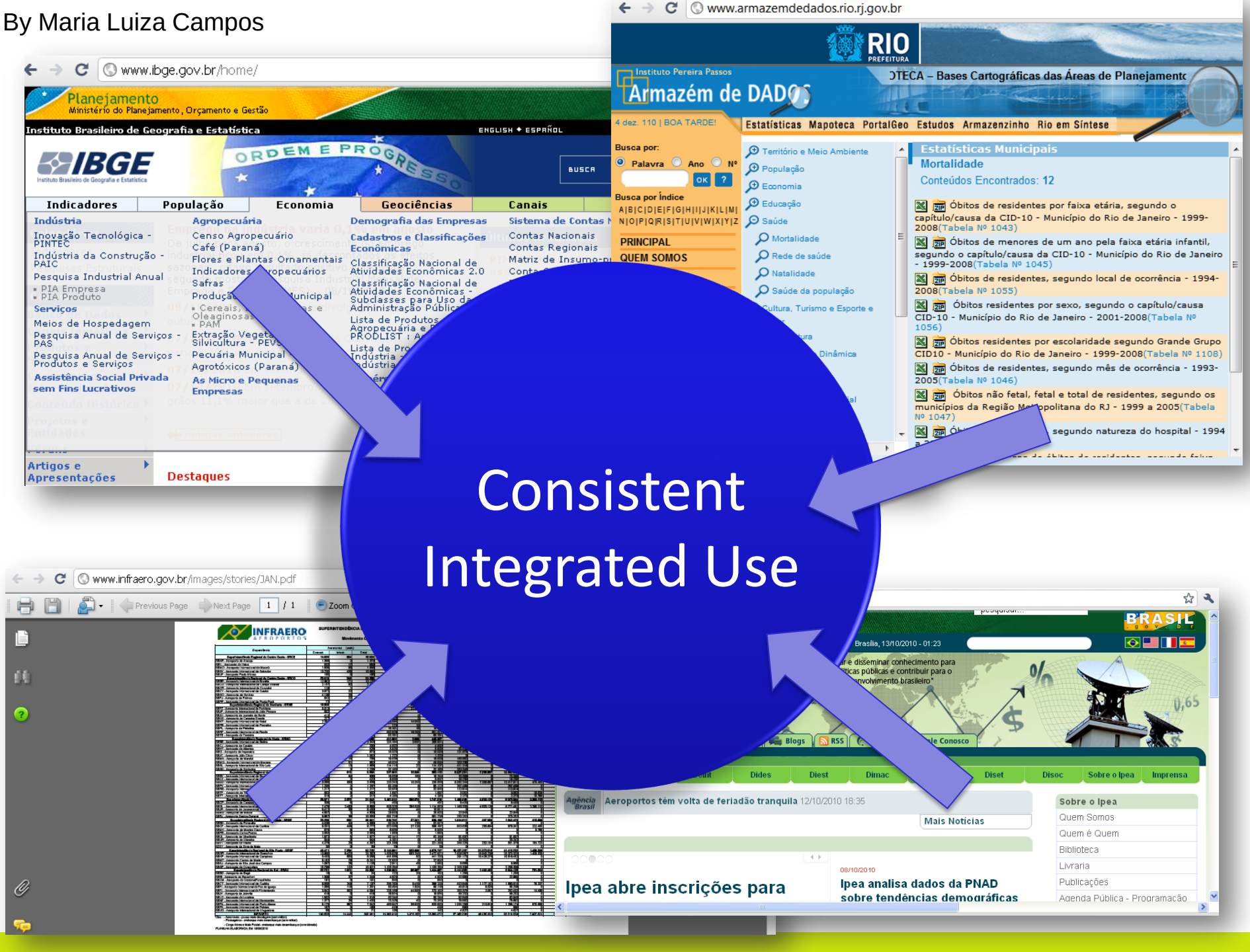


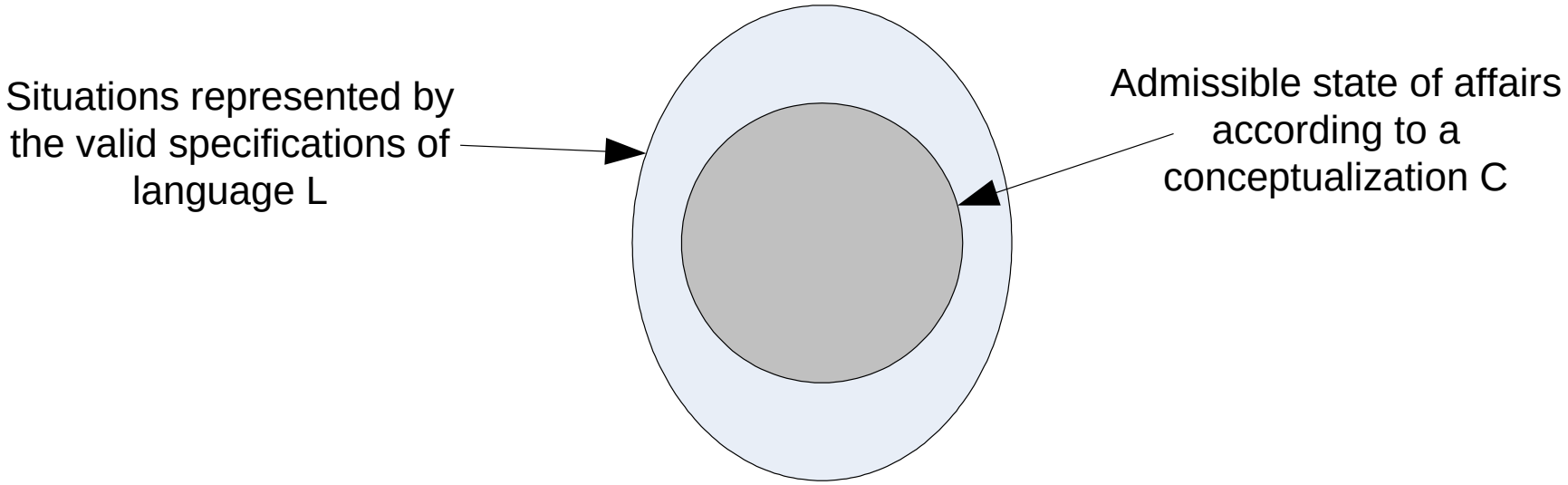
By J.P.A. Almeida

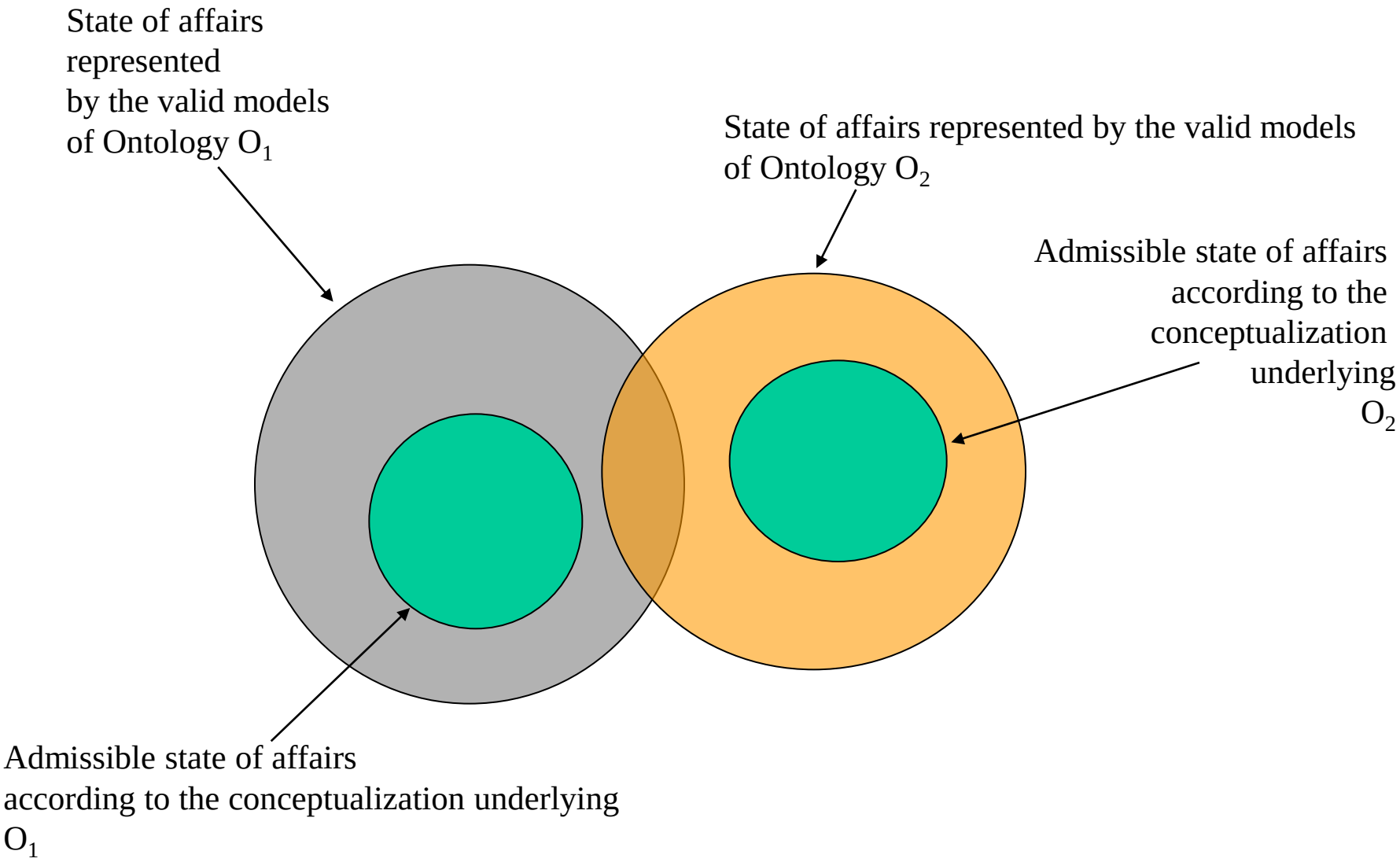


"Linking Open Data cloud diagram, by Richard Cyganiak and Anja Jentzsch. http://lod-cloud.net/"

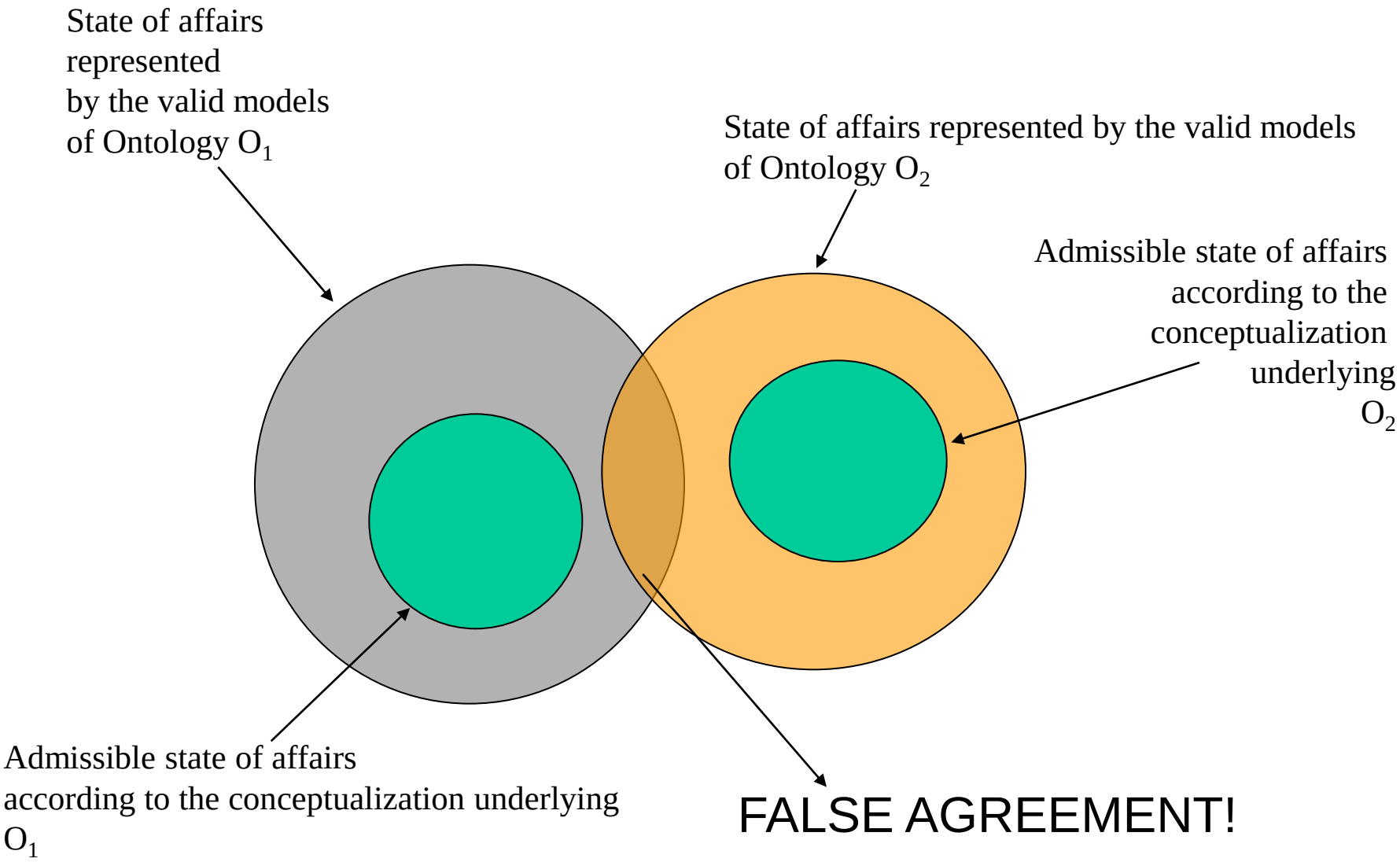
By Maria Luiza Campos




Situations represented by the valid specifications of language L
Admissible state of affairs according to a conceptualization C



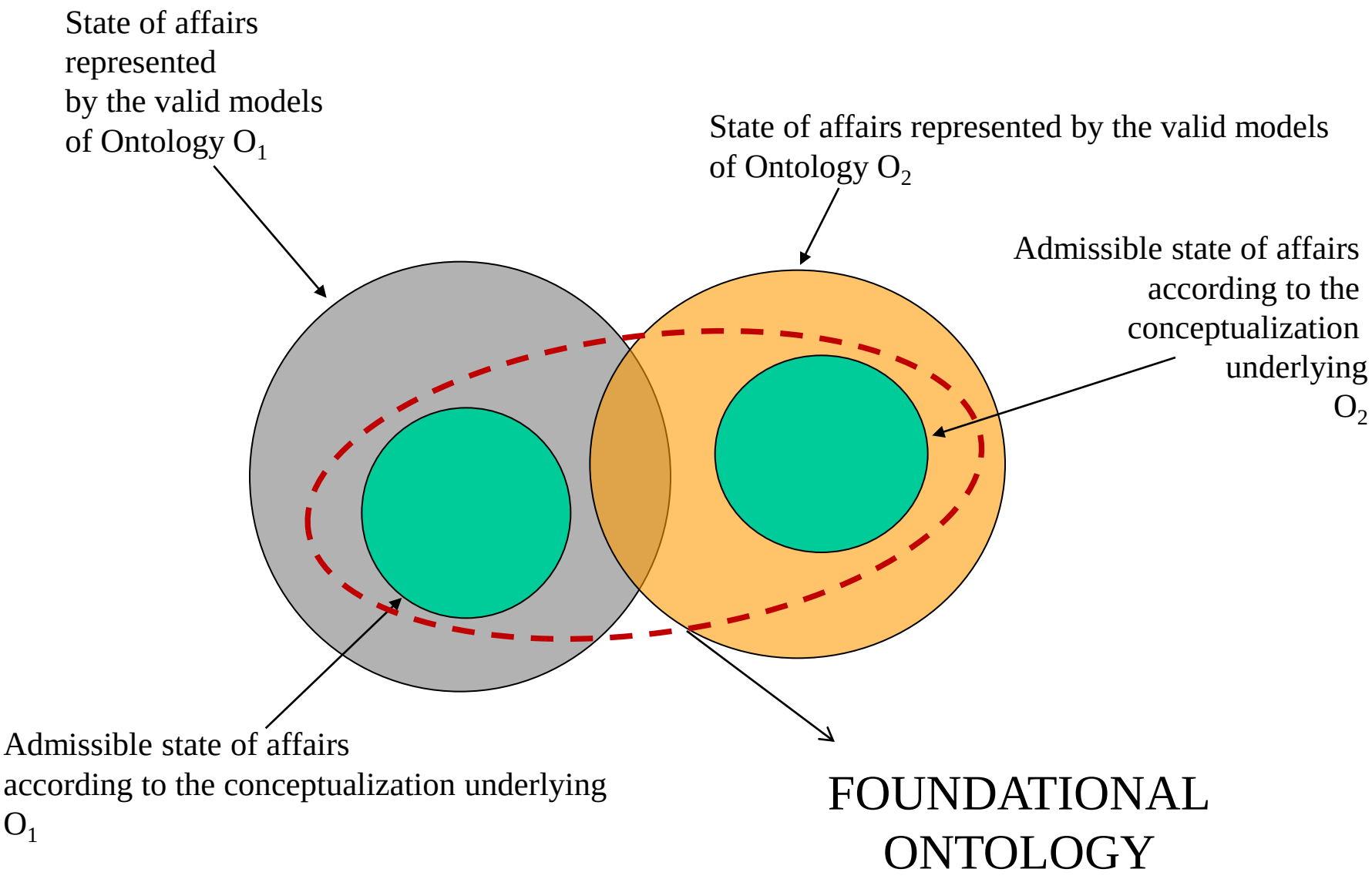
By Nicola Guarino

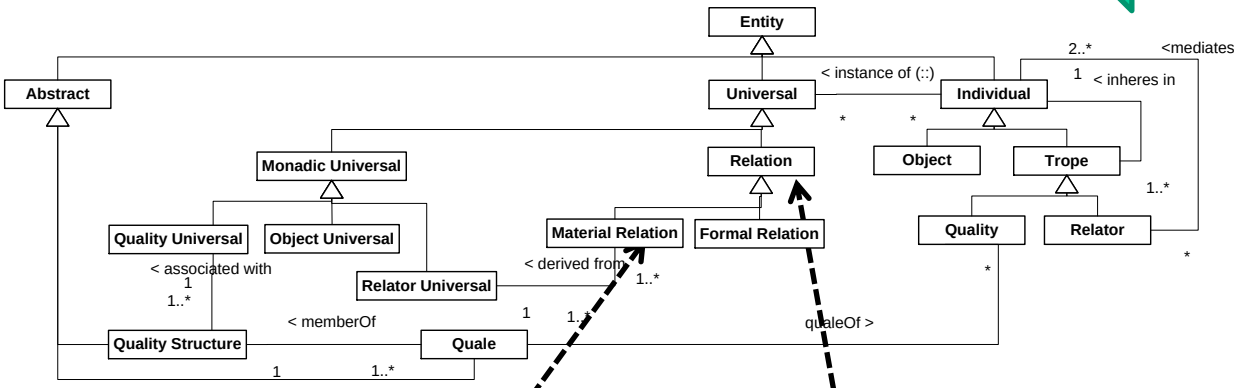


By Nicola Guarino

"one of the main reasons that so many online market makers have foundered [is that] the transactions they had viewed as simple and routine actually involved *many subtle distinctions in terminology and meaning"*

(Harvard Business Review)


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
FOUNDATIONAL ONTOLOGY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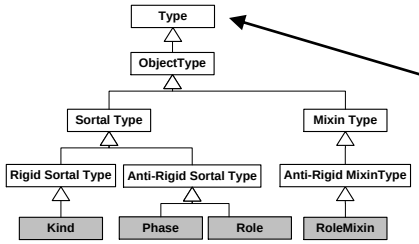
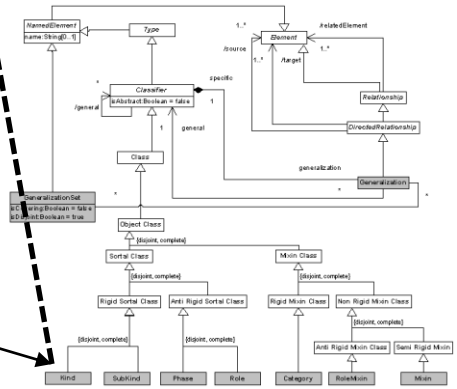

Type
ObjectType
Sortal Type
Mixin Type
Rigid Sortal Type
Anti-Rigid Sortal Type
Anti-Rigid MixinType
Kind
Phase
Role
RoleMixin

R’



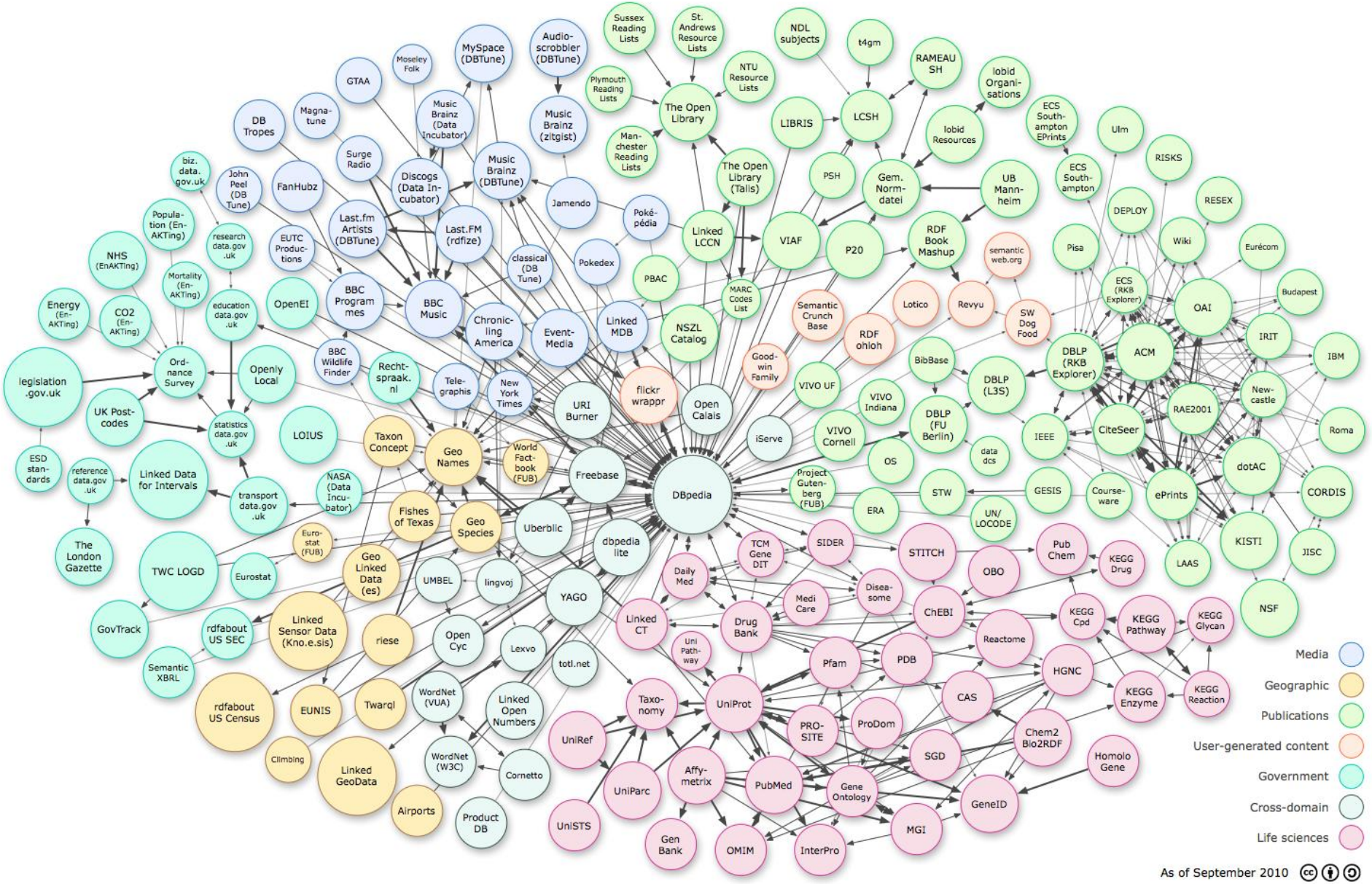
The alternative to ontology is not “non-ontology” but bad ontology!

Relevant Reference

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.

Guizzardi, G., Halpin, T. Ontological Foundations for Conceptual Modeling. Applied Ontology. , v.3, p.91 - 110, 2008.

EXAMPLE OF SEMANTIC INTEROPERABILITY PROBLEMS IN LIGHTWEIGHT ONTOLOGIES



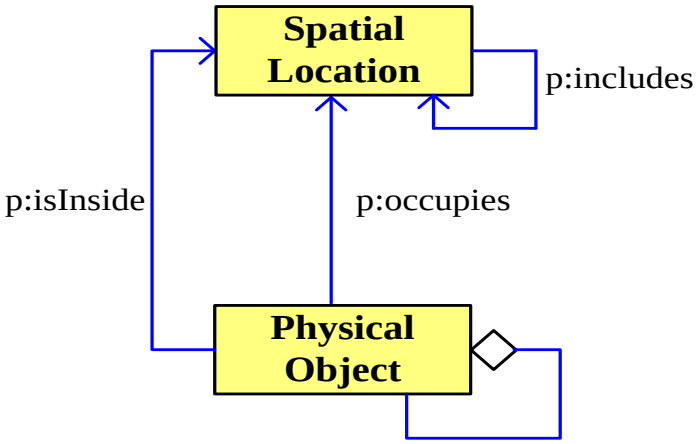
"Linking Open Data cloud diagram, by Richard Cyganiak and Anja Jentzsch. http://lod-cloud.net/"

Fragment of a Spatial Ontology

- Constraints:

  For every two arbitrary physical objects X and Y, if there are two spatial locations A, B, such that X occupies A, Y occupies B, and A is equal to B, then X and Y are the same physical object.

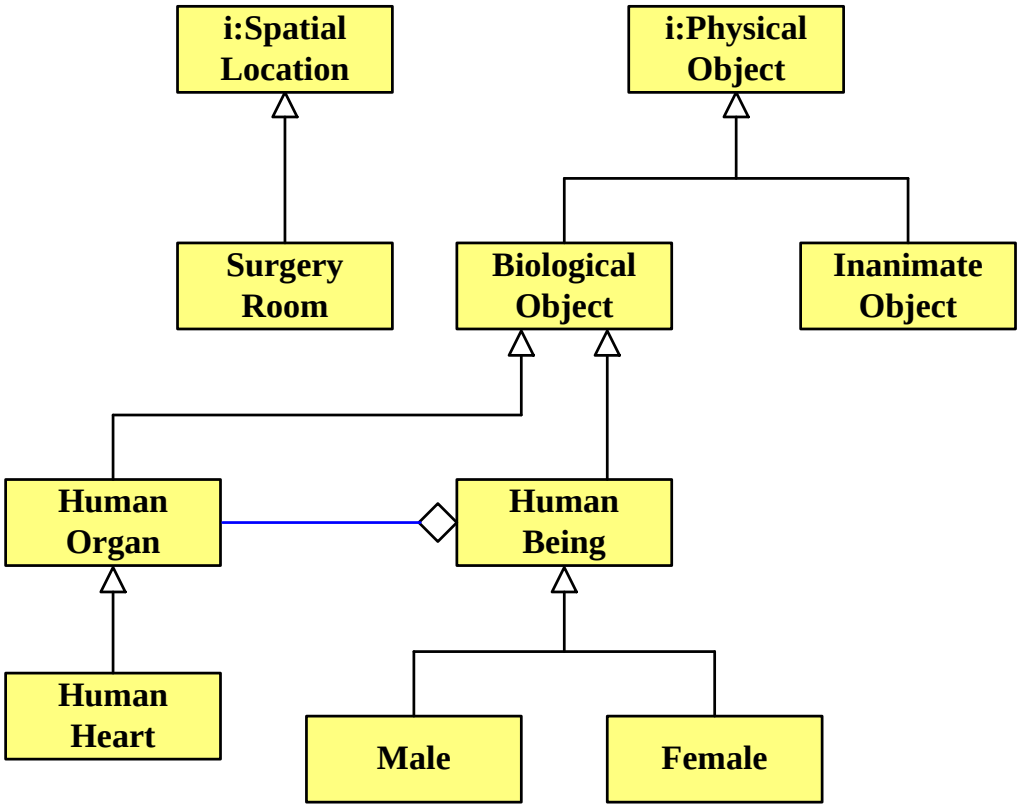
  For every two arbitrary physical objects X and Y, X is equal to Y if and only if they have the same parts.



- This ontology could be used by a GPS sensor agent to provide a service to track the location of physical objects in a context-aware platform

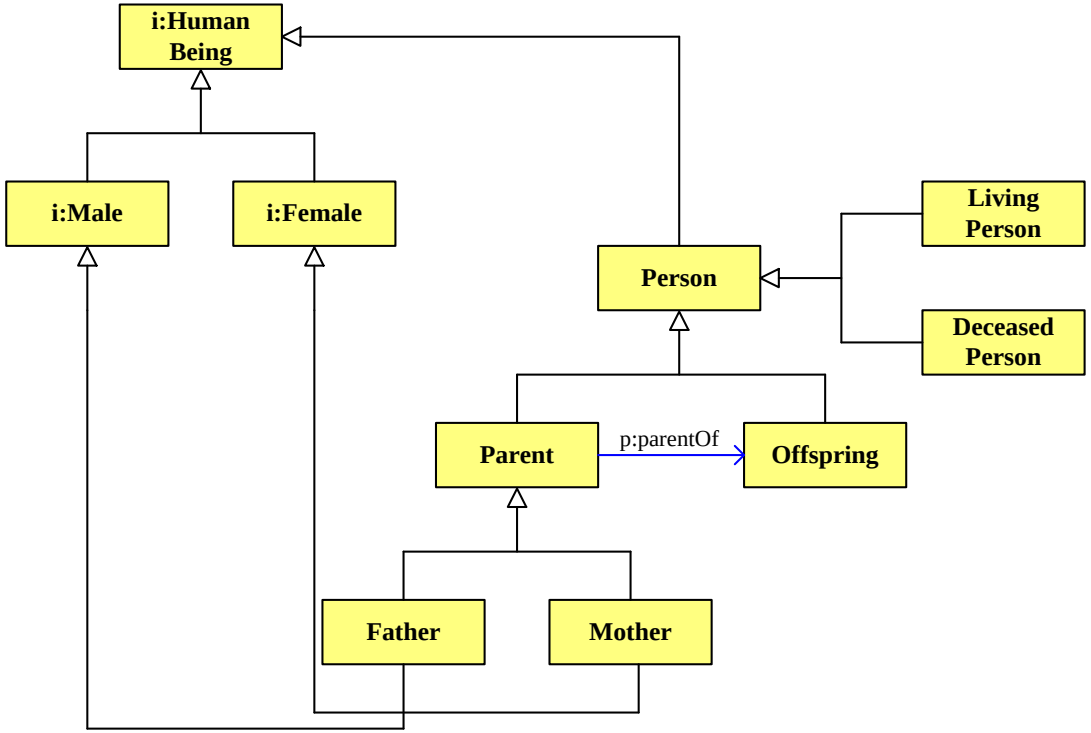
Fragment of a Hospital Ontology

- This ontology could be used for defining applications for checking location of patients, locate organs for transplants, and so forth.



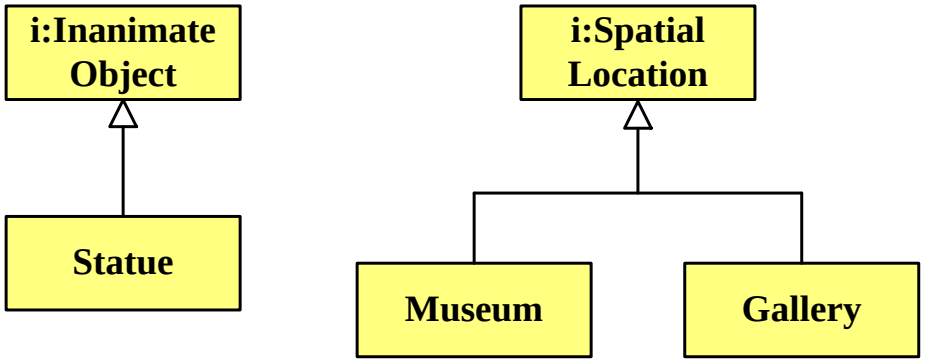
Fragment of a Legal Ontology

- This ontology could be used by legal applications to refer to the medical histories of people; to have access to their personal data (e.g., blood type, skin colour, fingerprints, height, weight); to differentiate people by sex; or to maintain a record of living and deceased people in a community.



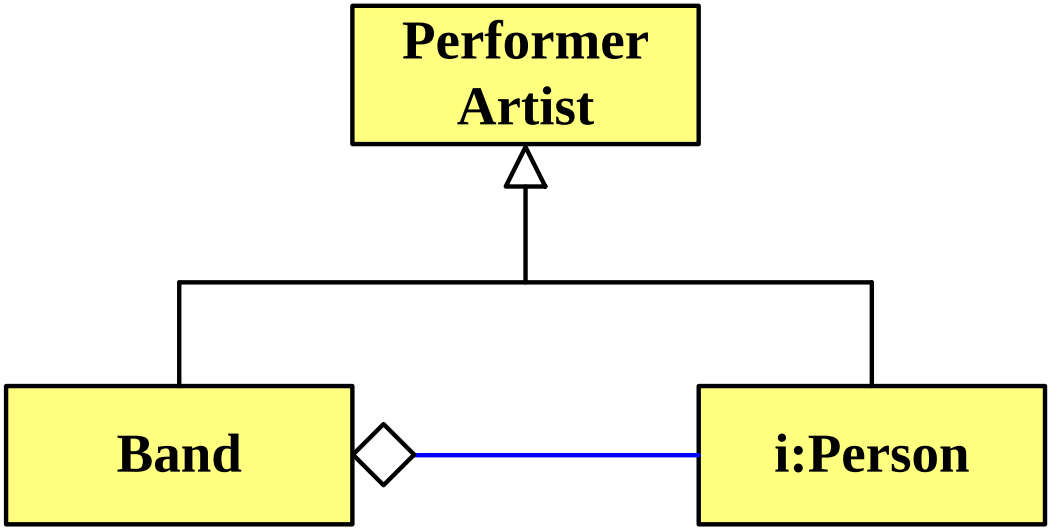
Fragment of a Museum Ontology

- This ontology could be used to define spatial locations of entities like galleries within a museum, or inanimate objects like statues. These imported ontologies allow for applications to locate objects within the museum (e.g., statues, paintings



Fragment of a Music Ontology

- This ontology could be used to by an *Event Advisor* to notifies users about upcoming events that match their personal interests.



Possible Interoperability Problems

1. **An application using the Hospital Ontology can derive the following wrong information:**

   if a human being receives a heart transplant, he/she becomes a different human being.

   Similarly, consider a tourist route planner application that plans a route including tourist points of interest or events never seen by the user of the application. Due to an accident, a human statue known by the user has lost a hand. The application will consider this statue different from the one the user visited; therefore it will be included in the route plan by error. This example uses a physical object (statue) for the purpose of illustration of the problem, but an analogous situation can be imagined with events such as a play or a concert

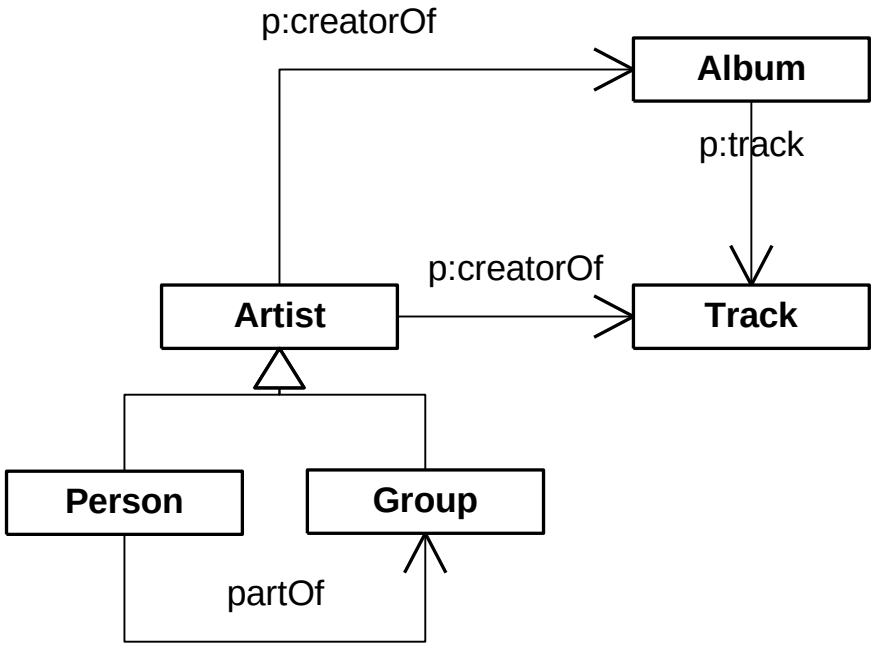
Possible Interoperability Problems

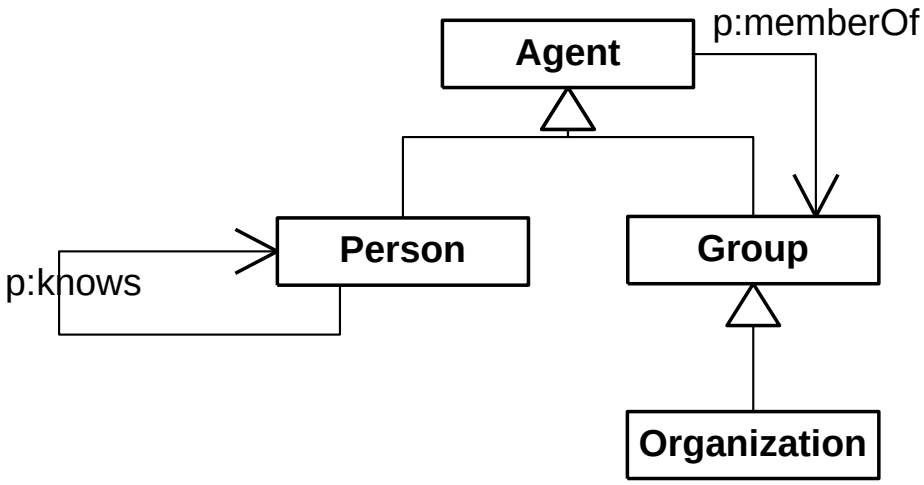
2. Suppose an application for the obituary section of a music newspaper, which sends information about artists who die. It uses the Musical ontology, which imports the Legal ontology (to reuse the concept of person).
    - The application will malfunction and it will send information about every person who dies, since [according to the Music Ontology] every person is a performer artist. The intention in the ontology is to represent that either persons or bands are performer artists. However, as a side effect, the ontology also states that every person is a performer artist

Possible Interoperability Problems

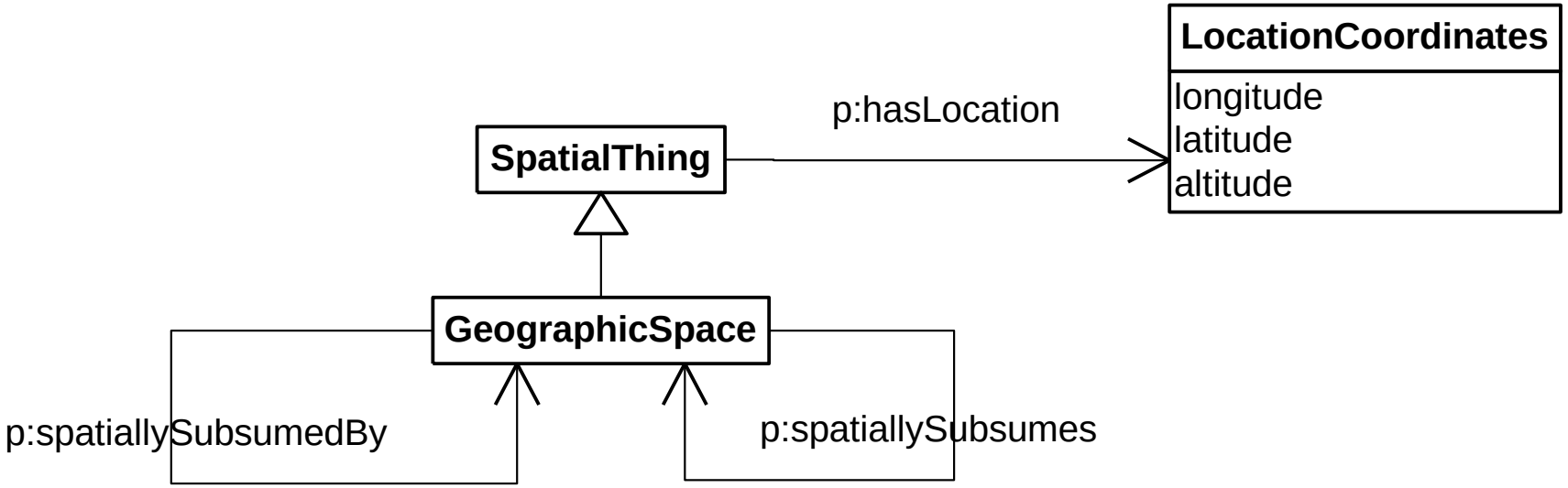
3. Since the Music ontology imports the Legal ontology, which imports the Medical ontology, the heart (and all other parts) of a person can be inferred to be part of a band, due to transitivity of the "*partOf*" relation, which can cause undesirable inferences to be derived

Music Ontology vs. MusicBrainz and FOAF





Spatial Ontology vs. SOUPA



SOUPA integrates parts of several other ontologies such as FOAF, DAML-Time, OpenCyC and OpenGIS, Rei Policy ontology and *MoGATU BDI*

Relevant Reference

Guizzardi, G. “The Role of Foundational Ontology for Conceptual Modeling and Domain Ontology Representation”, 7th International Baltic Conference on Databases and Information Systems, Vilnius, Lithuania, 2006.

“What are ontologies and why we need them?”

nemo

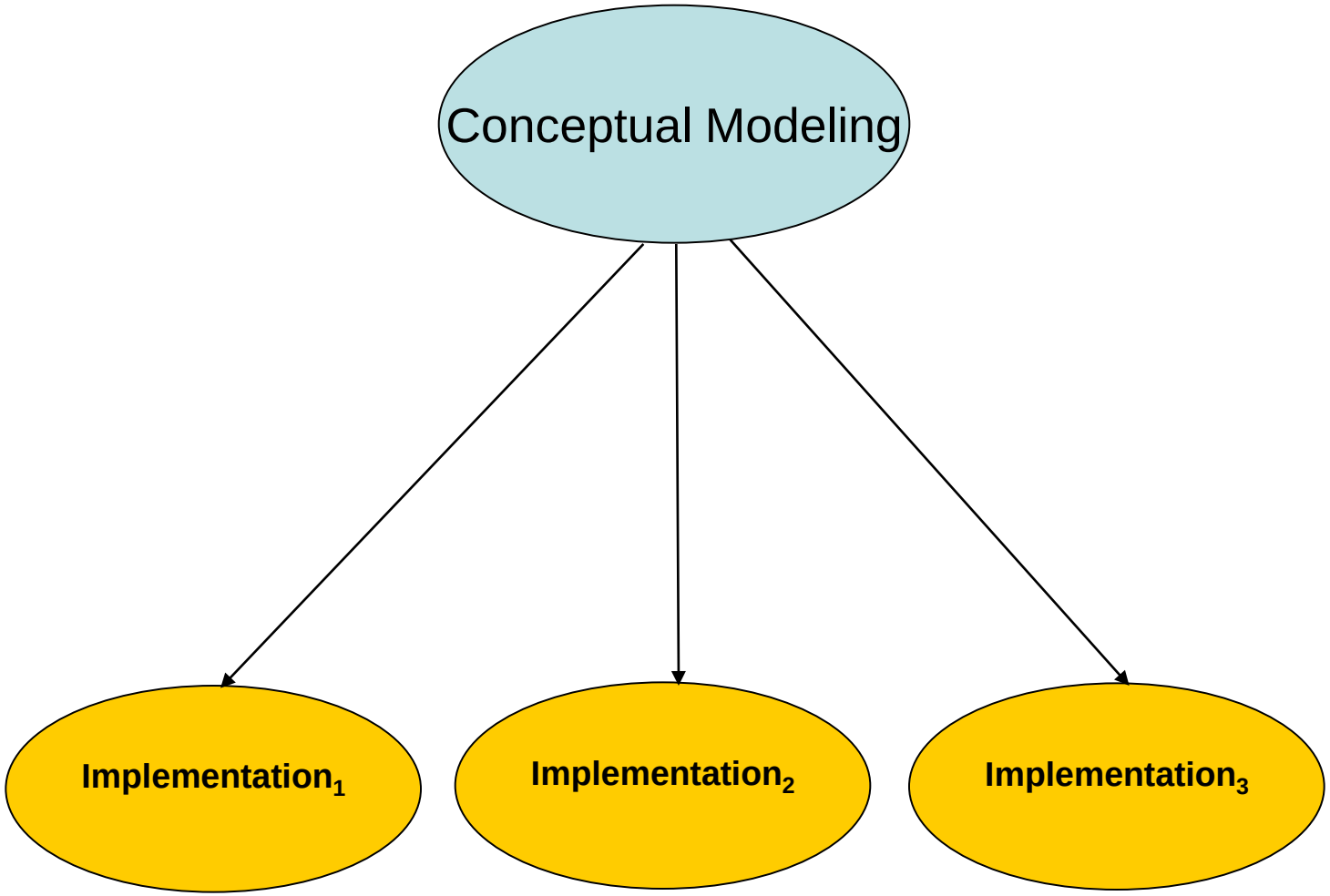
1. *Reference Model of Consensus* to support different types of *Semantic Interoperability* Tasks
2. Explicit, declarative and machine processable artifact coding a domain model to enable efficient automated reasoning

REFERENCE:

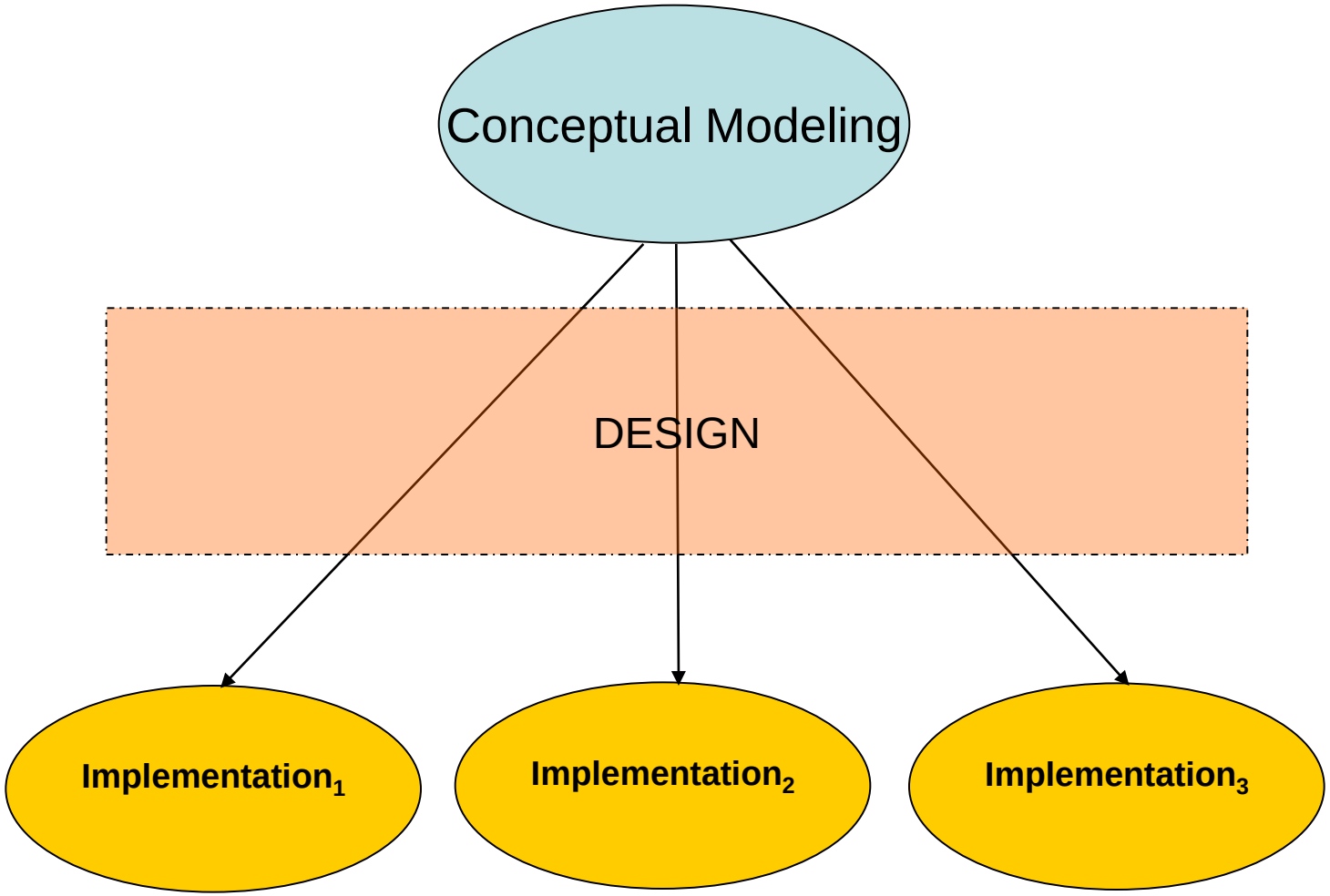
GUIZZARDI, G., Theoretical Foundations and Engineering Tools for Building Ontologies as Reference Conceptual Models, Semantic Web Journal, Editors-in-Chief: Pascal Hitzler and Krzysztof Janowicz, IOS Press, Amsterdam, 2011. (Personal Response to the Special Issue on “What is missing on the Semantic Web?”).

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

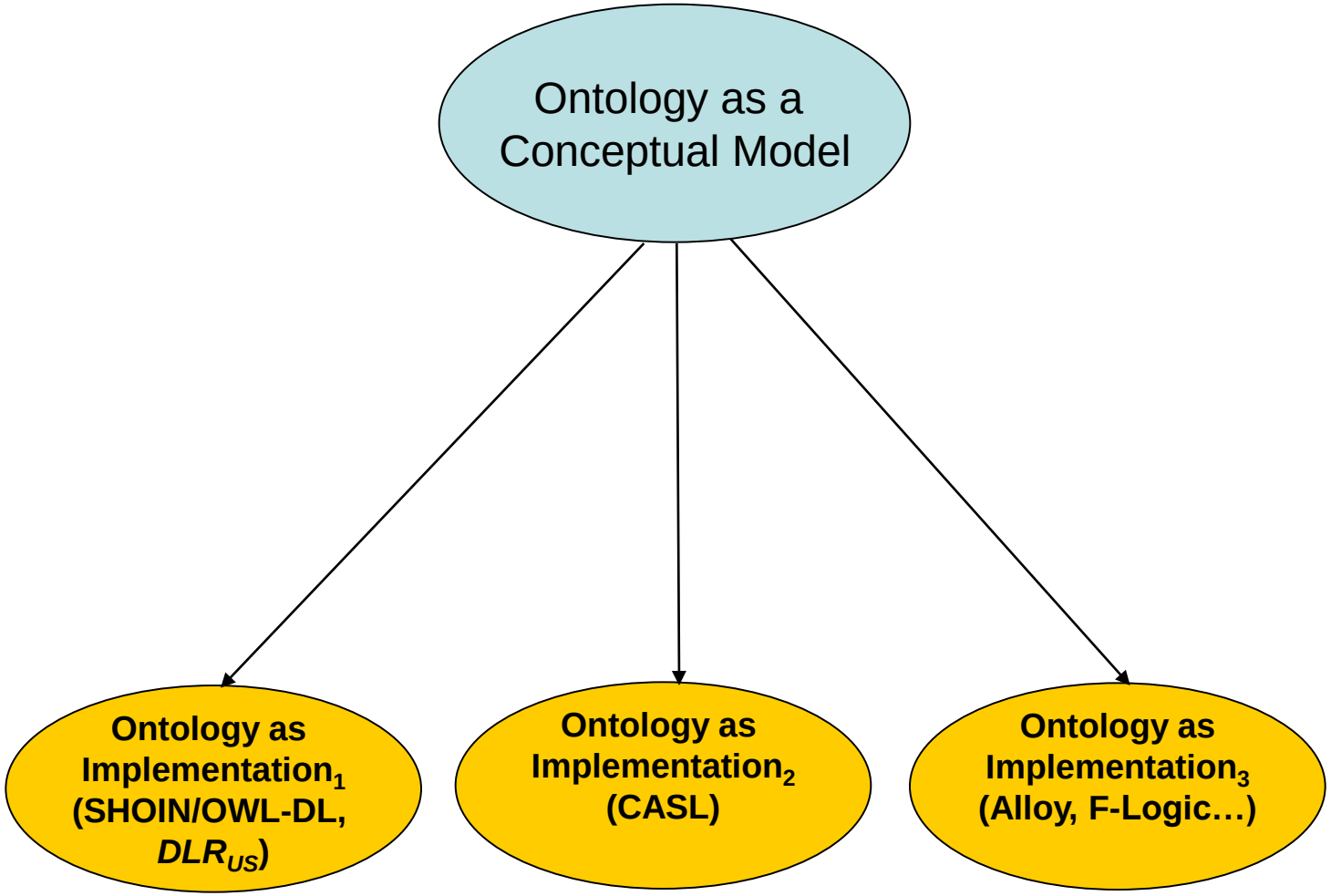
A Software Engineering view…



A Software Engineering view…



…transported to Ontological Engineering



“Explore the domain

This should be clear from the business requirements - it might be food or music or gardening or...

Concentrate on modelling real (physical and metaphysical) *things* not web pages - try to blank from your mind all thoughts of the resulting web site.

This work should never stop - you need to do this through the lifetime of the project as you refine your understanding.”

Michael Smethurst, BBC
http://www.bbc.co.uk/blogs/radiolabs/2009/01/how_we_make_websites.shtml

“Identify your domain objects and the relationships between them

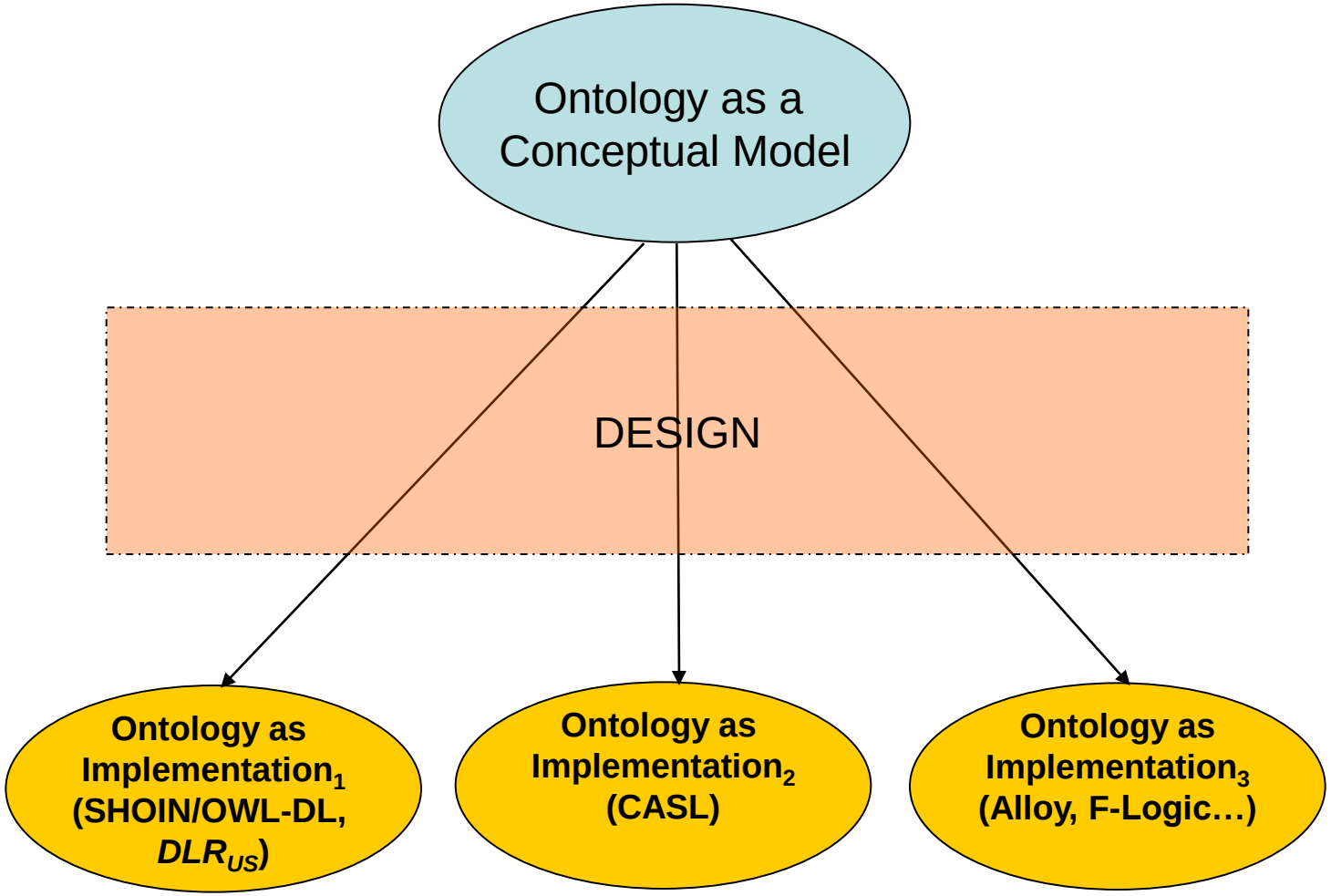
As you chat and sketch with your domain expert you should build up a picture of the types of things they're concerned with. As your knowledge of the domain increases you'll build up a picture of how your objects interlink.

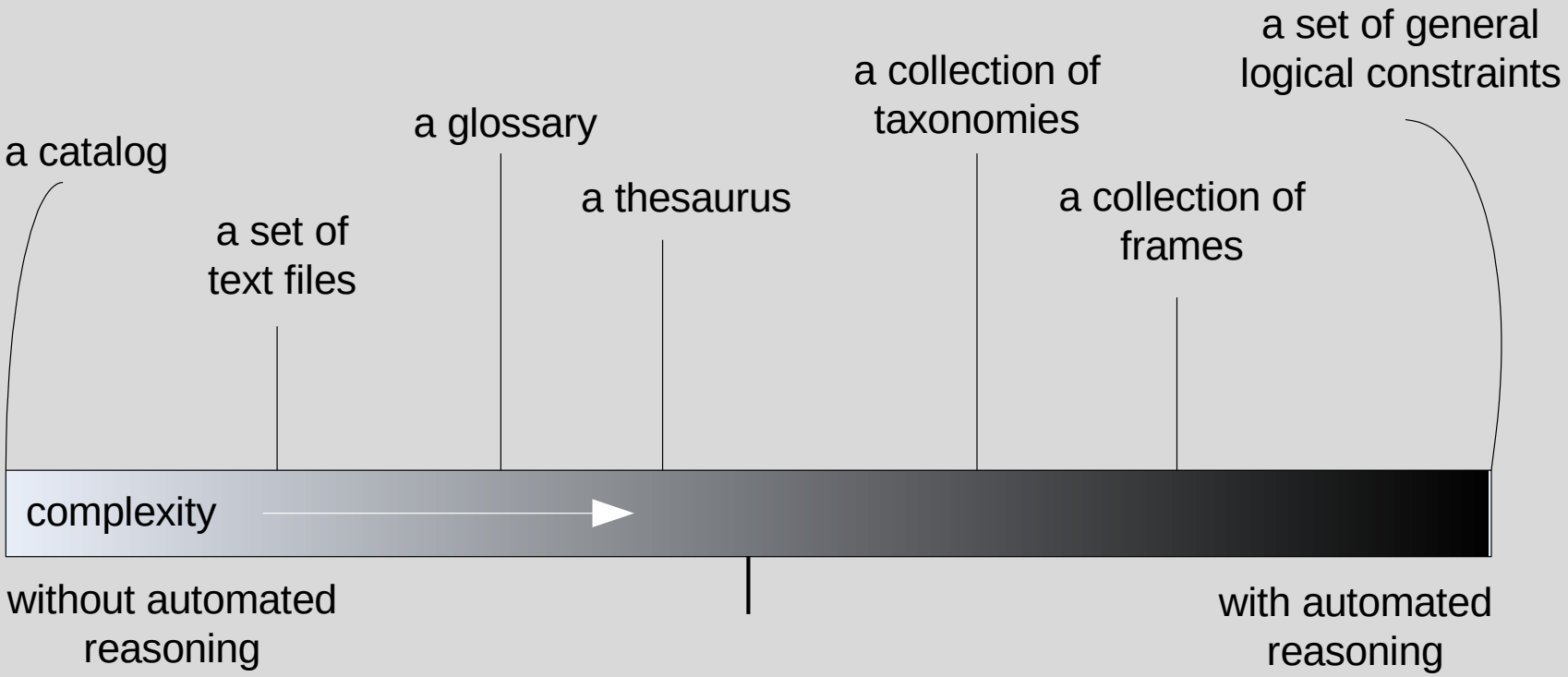
Bear in mind you're trying to capture the domain ontology - this isn't about sketching database schemas.

The resulting domain model will inform the rest of your project and should be one of the few *artifacts* your project ever creates.”

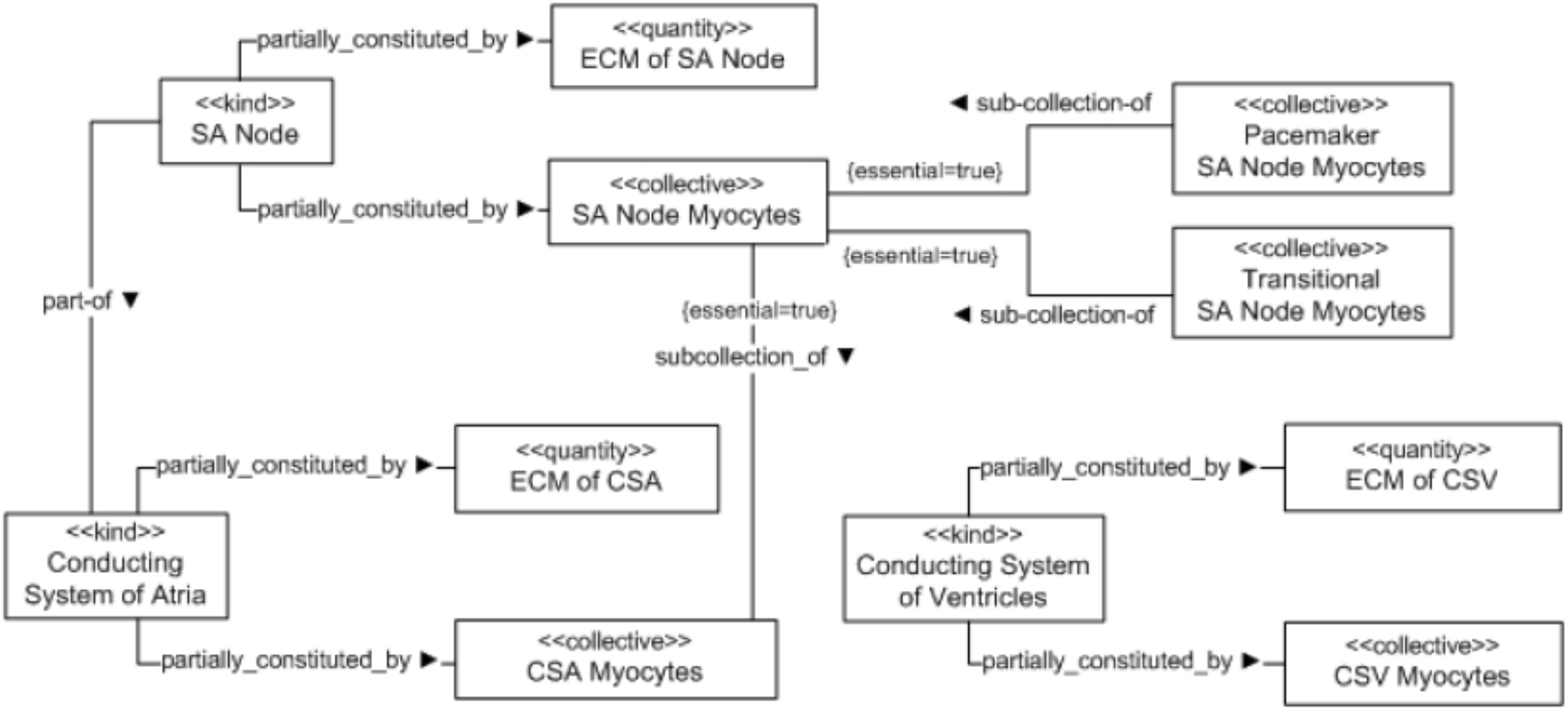
Michael Smethurst, BBC
http://www.bbc.co.uk/blogs/radiolabs/2009/01/how_we_make_websites.shtml

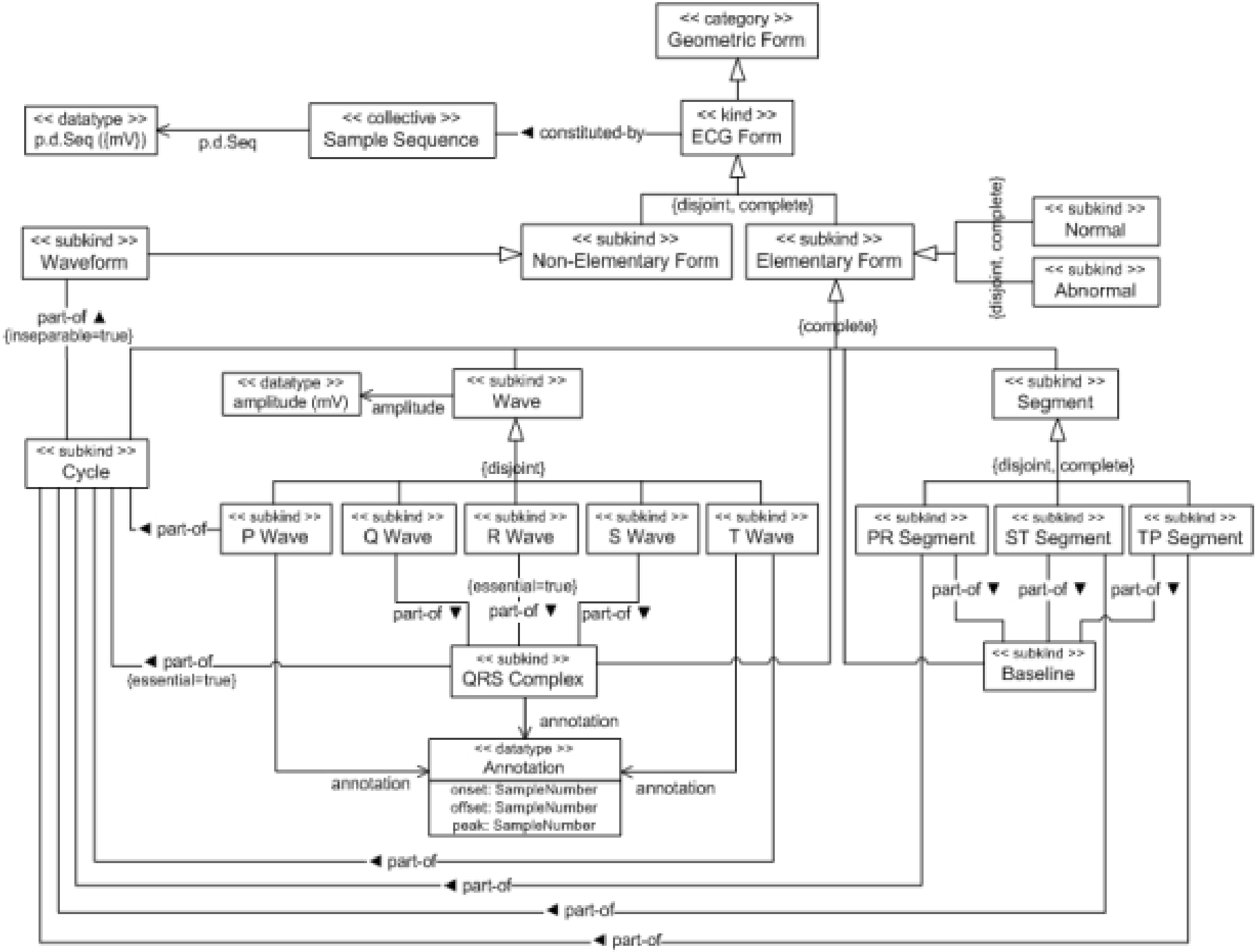
…transported to Ontological Engineering

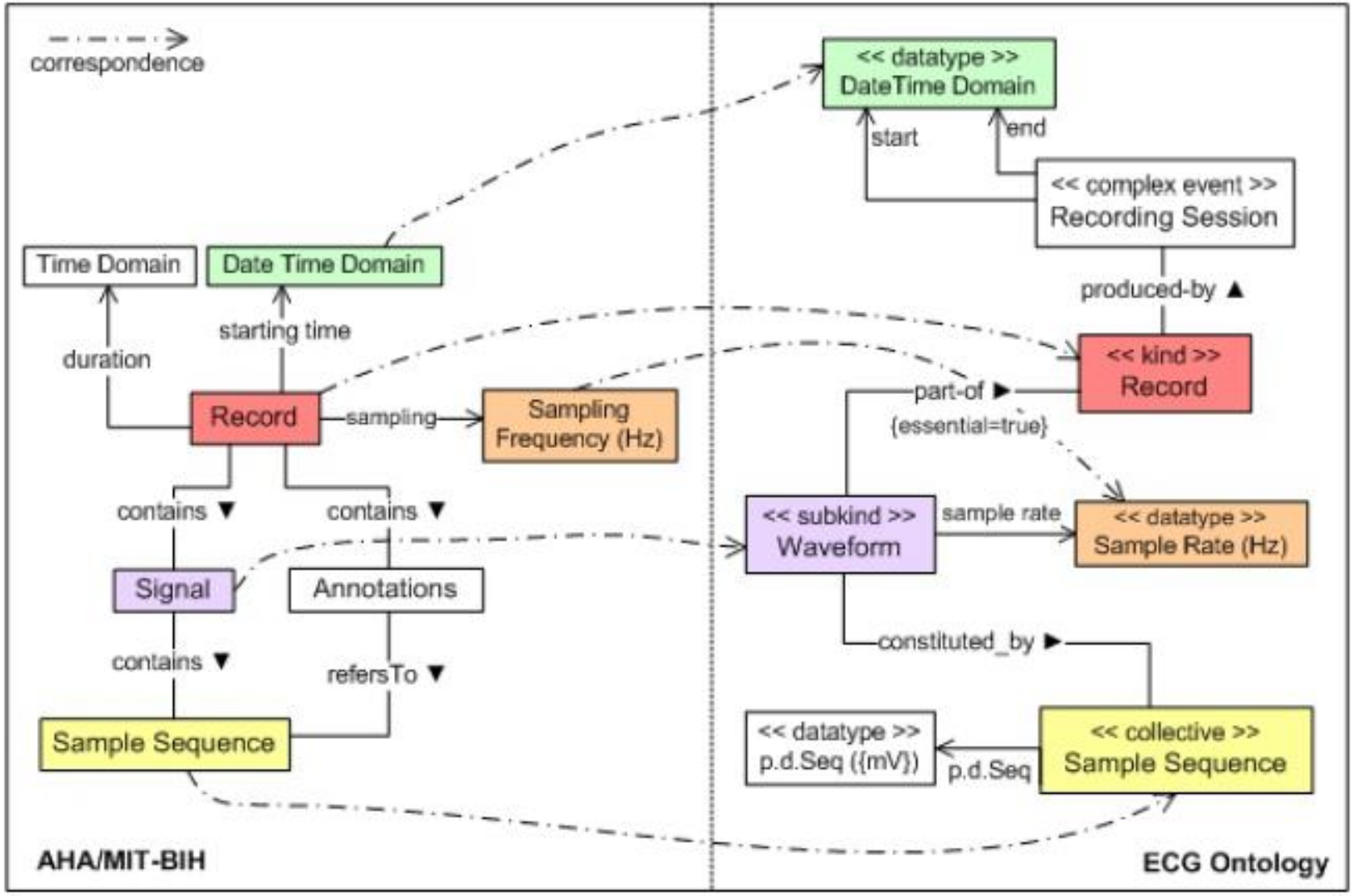


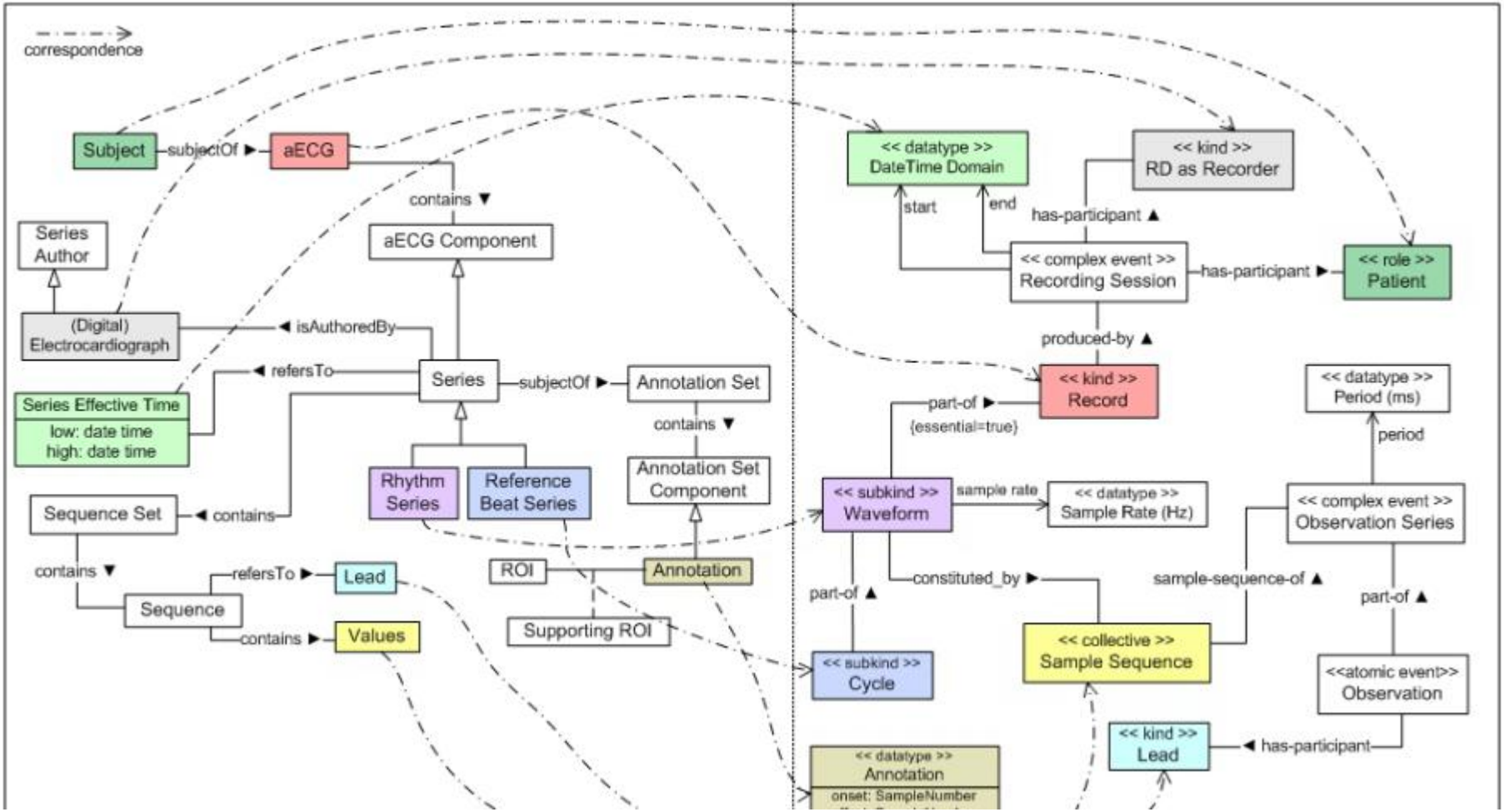

a catalog
a set of text files
a glossary
a thesaurus
a collection of taxonomies
a collection of frames
a set of general logical constraints
complexity
without automated reasoning
with automated reasoning

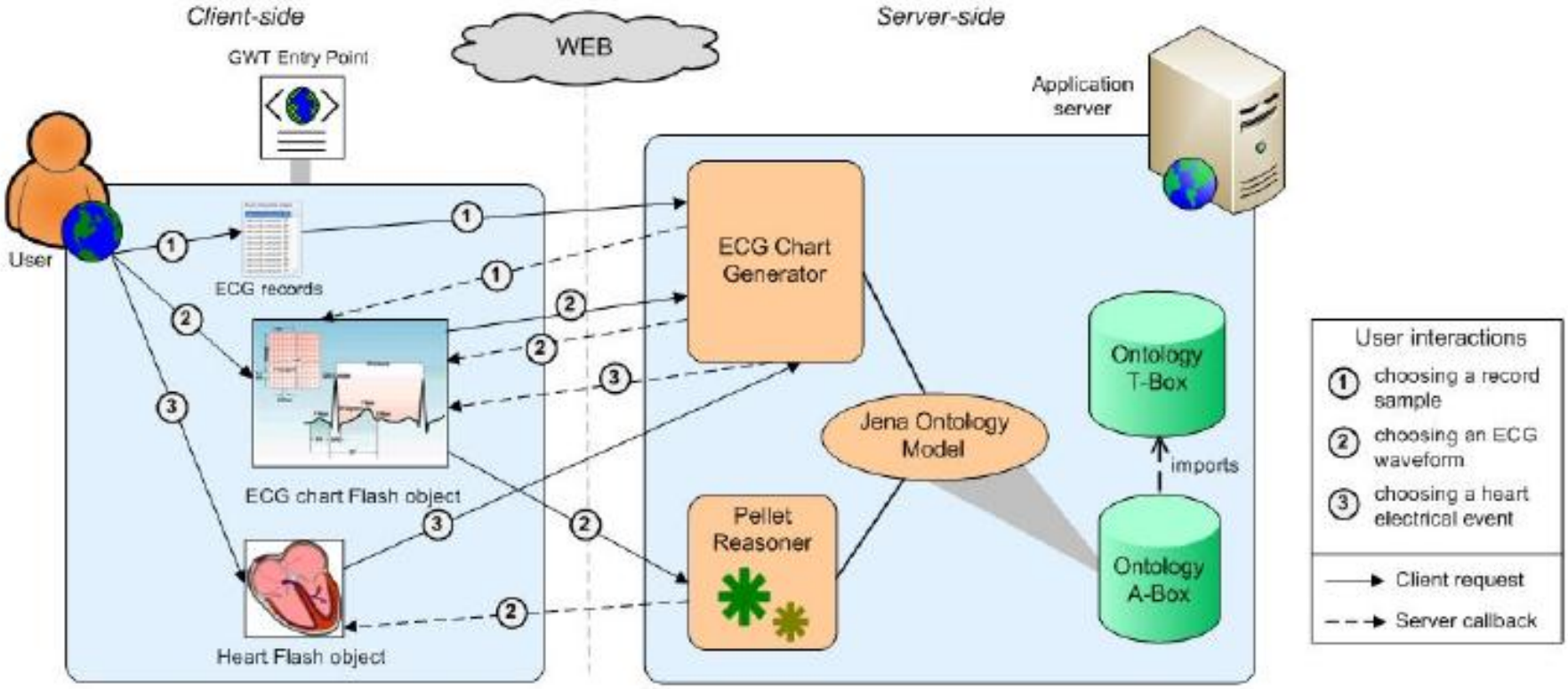
Example: The ECG Ontology




<< category >>
Geometric Form
<< datatype >>
p.d.Seq ([mV])
p.d.Seq
<< collective >>
Sample Sequence
constituted-by
<< kind >>
ECG Form
{disjoint, complete}
<< subkind >>
Waveform
<< subkind >>
Non-Elementary Form
<< subkind >>
Elementary Form
{disjoint, complete}
<< subkind >>
Normal
<< subkind >>
Abnormal
part-of
{inseparable=true}
{complete}
<< datatype >>
amplitude (mV)
amplitude
<< subkind >>
Wave
<< subkind >>
Segment
<< subkind >>
Cycle
{disjoint}
{disjoint, complete}
part-of
<< subkind >>
P Wave
<< subkind >>
Q Wave
<< subkind >>
R Wave
<< subkind >>
S Wave
<< subkind >>
T Wave
<< subkind >>
PR Segment
<< subkind >>
ST Segment
<< subkind >>
TP Segment
{essential=true}
part-of
part-of
part-of
part-of
part-of
part-of
{essential=true}
<< subkind >>
QRS Complex
<< subkind >>
Baseline
annotation
<< datatype >>
Annotation
onset: SampleNumber
offset: SampleNumber
peak: SampleNumber
annotation
annotation
part-of
part-of
part-of
part-of


correspondence
<< datatype >>
DateTime Domain
start
end
<< complex event >>
Recording Session
Time Domain
Date Time Domain
produced-by
starting time
duration
<< kind >>
Record
part-of
{essential=true}
Record
sampling
Sampling
Frequency (Hz)
contains
contains
<< subkind >>
Waveform
sample rate
<< datatype >>
Sample Rate (Hz)
Signal
Annotations
constituted_by
contains
refersTo
<< datatype >>
p.d.Seq ({mV})
p.d.Seq
<< collective >>
Sample Sequence
Sample Sequence
AHA/MIT-BIH
ECG Ontology


correspondence
Subject
subjectOf
aECG
contains
aECG Component
Series Author
(Digital) Electrocardiograph
isAuthoredBy
refersTo
Series
subjectOf
Annotation Set
Series Effective Time
low: date time
high: date time
contains
Annotation Set Component
Rhythm Series
Reference Beat Series
Sequence Set
contains
contains
refersTo
Lead
Sequence
contains
Values
ROI
Annotation
Supporting ROI
<< datatype >>
DateTime Domain
<< kind >>
RD as Recorder
start
end
has-participant
<< complex event >>
Recording Session
has-participant
<< role >>
Patient
produced-by
<< kind >>
Record
part-of
{essential=true}
<< datatype >>
Period (ms)
period
<< subkind >>
Waveform
sample rate
<< datatype >>
Sample Rate (Hz)
<< complex event >>
Observation Series
part-of
constituted_by
sample-sequence-of
part-of
<< subkind >>
Cycle
<< collective >>
Sample Sequence
<<atomic event>>
Observation
<< kind >>
Lead
has-participant
<< datatype >>
Annotation
onset: SampleNumber

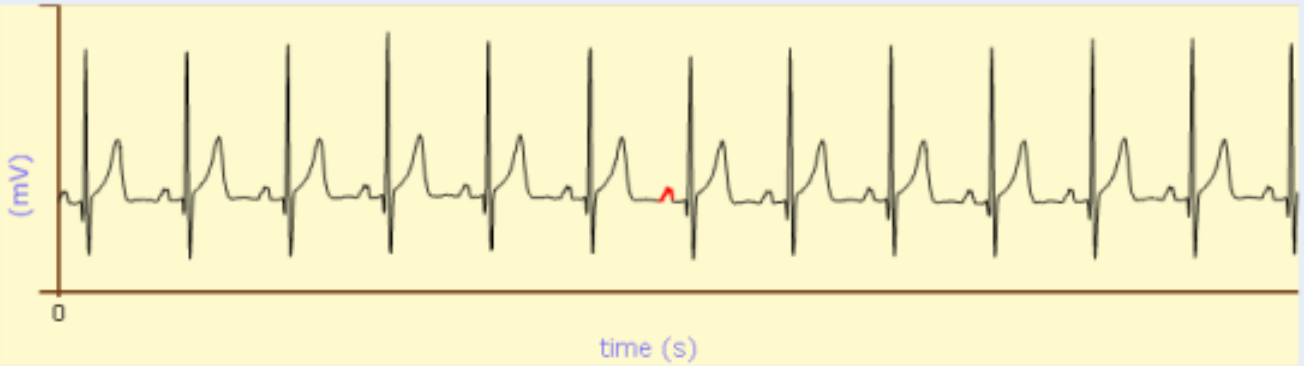

Client-side
GWT Entry Point
WEB
Server-side
Application server
User
ECG records
ECG chart Flash object
Heart Flash object
ECG Chart Generator
Jena Ontology Model
Pellet Reasoner
Ontology T-Box
imports
Ontology A-Box
User interactions
1 choosing a record sample
2 choosing an ECG waveform
3 choosing a heart electrical event
Client request
Server callback

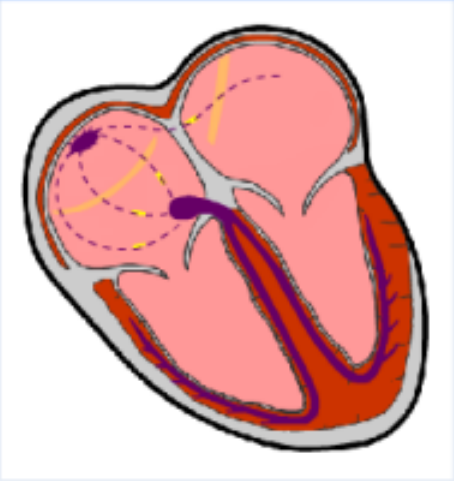
From the ECG to the heart electrophysiology: A reasoning-based web environment

ECG records base

record sel16483

Start





Asserted fact(s):

- The click was on the emphasized *pWave* in the ECG *waveform*.

Retrieved fact(s):

- It has been deemed a *normal pWave* by a referred cardiology expert.

Inferred fact(s):

- This *ECG form maps* a *normal* process of *depolarization of the conducting system of atria's myocytes* which is animated on the left. The function *to conduct cardiac electrical impulse* has been inferred *actually realized by* that process.

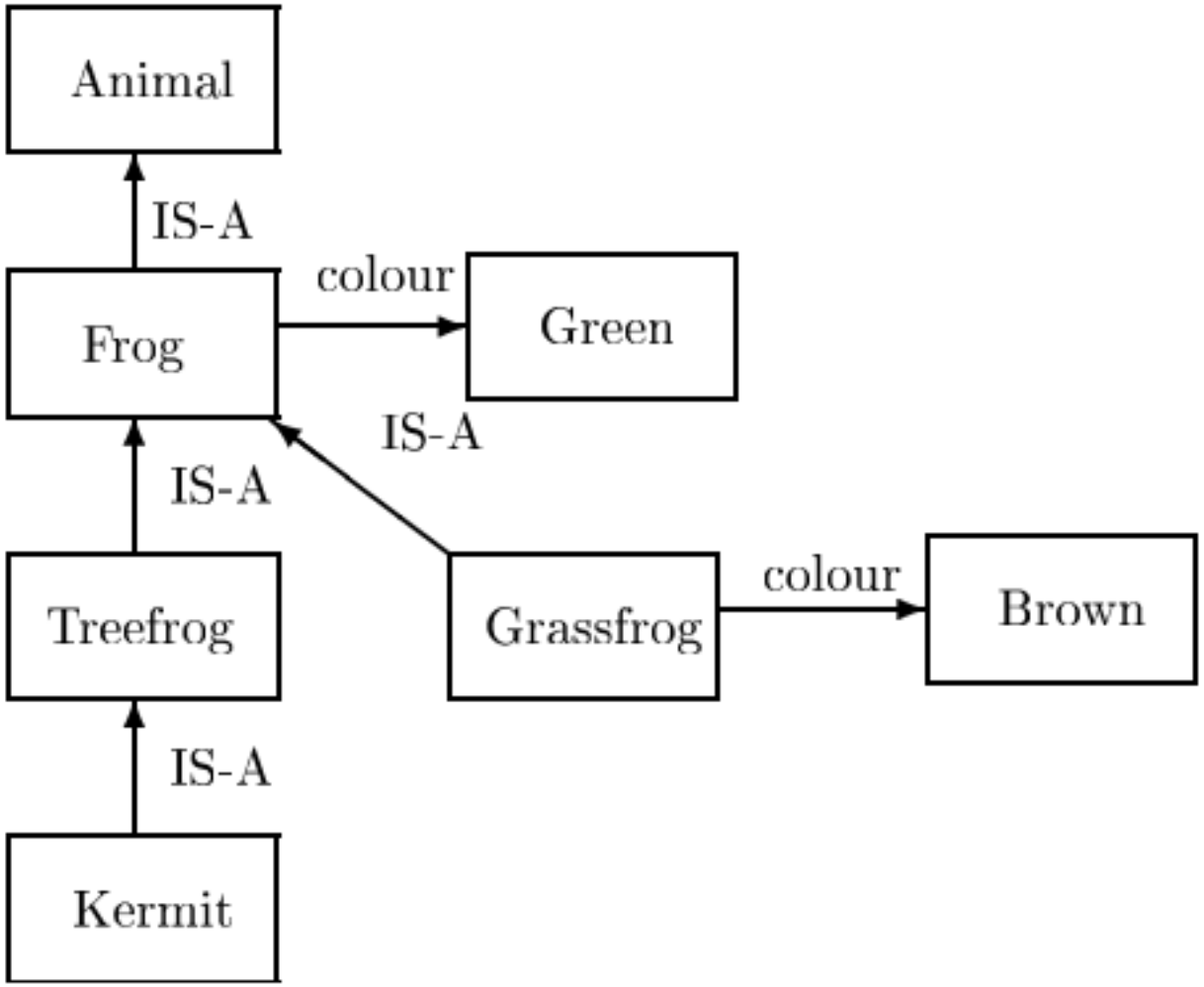
Relevant Reference

GONÇALVES, B.N.; GUIZZARDI, G.; PEREIRA FILHO, J.G., Using an ECG reference ontology for semantic interoperability of ECG data, Journal of Biomedical Informatics, Special Issue on Ontologies for Clinical and Translational Research, Editors: Barry Smith, Werner Ceusters and Richard H. Scheuermann, Elsevier, 2011.

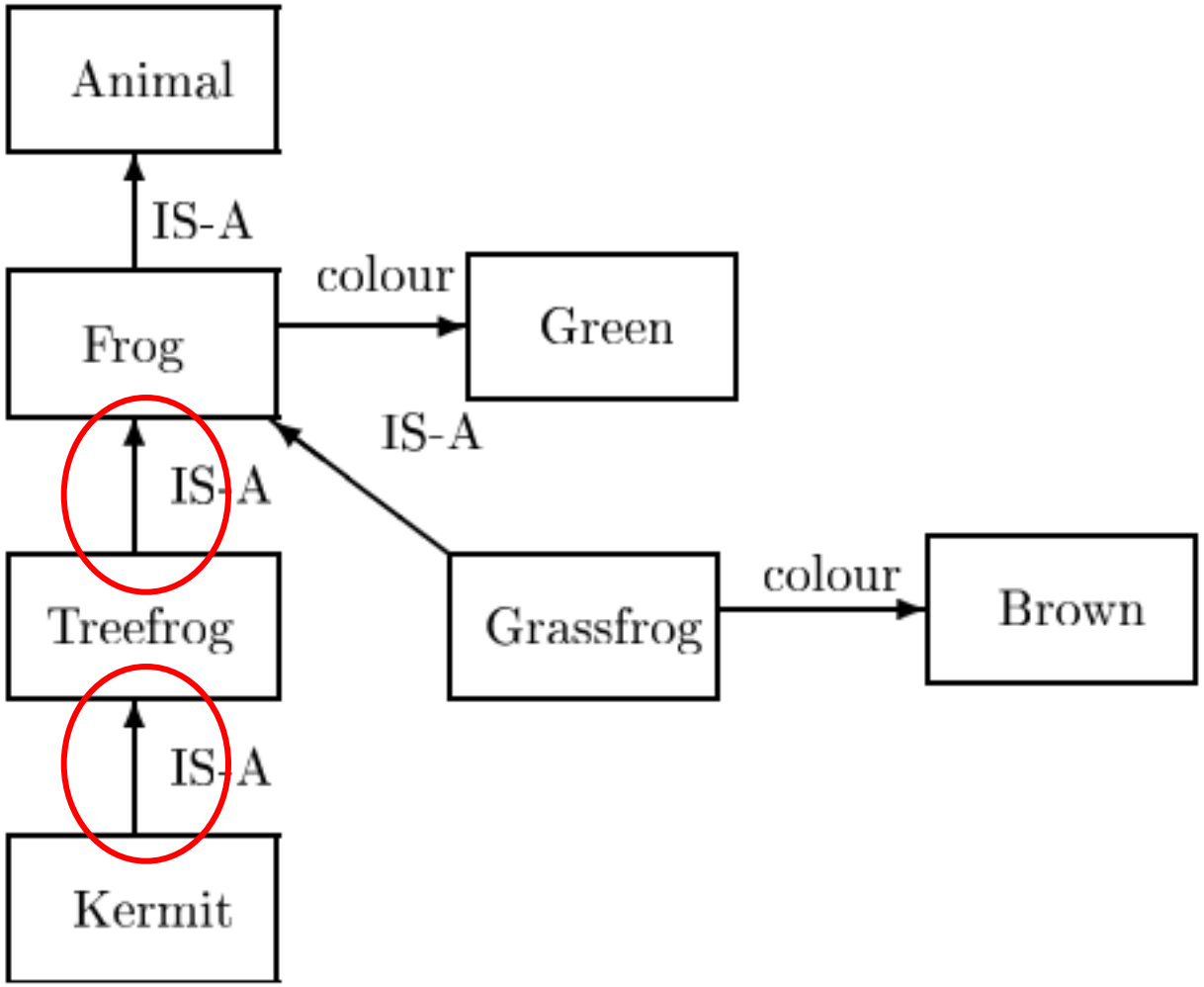
GONCALVES, B. N.; ZAMBORLINI, V. ; GUIZZARDI, G. An Ontological Analysis of the Electrocardiogram. ELECTRONIC JOURNAL OF COMMUNICATION, INFORMATION AND INNOVATION IN HEALTH, 2009.

2. We need ontology representations languages which are based on *Truly Ontological Distinctions*

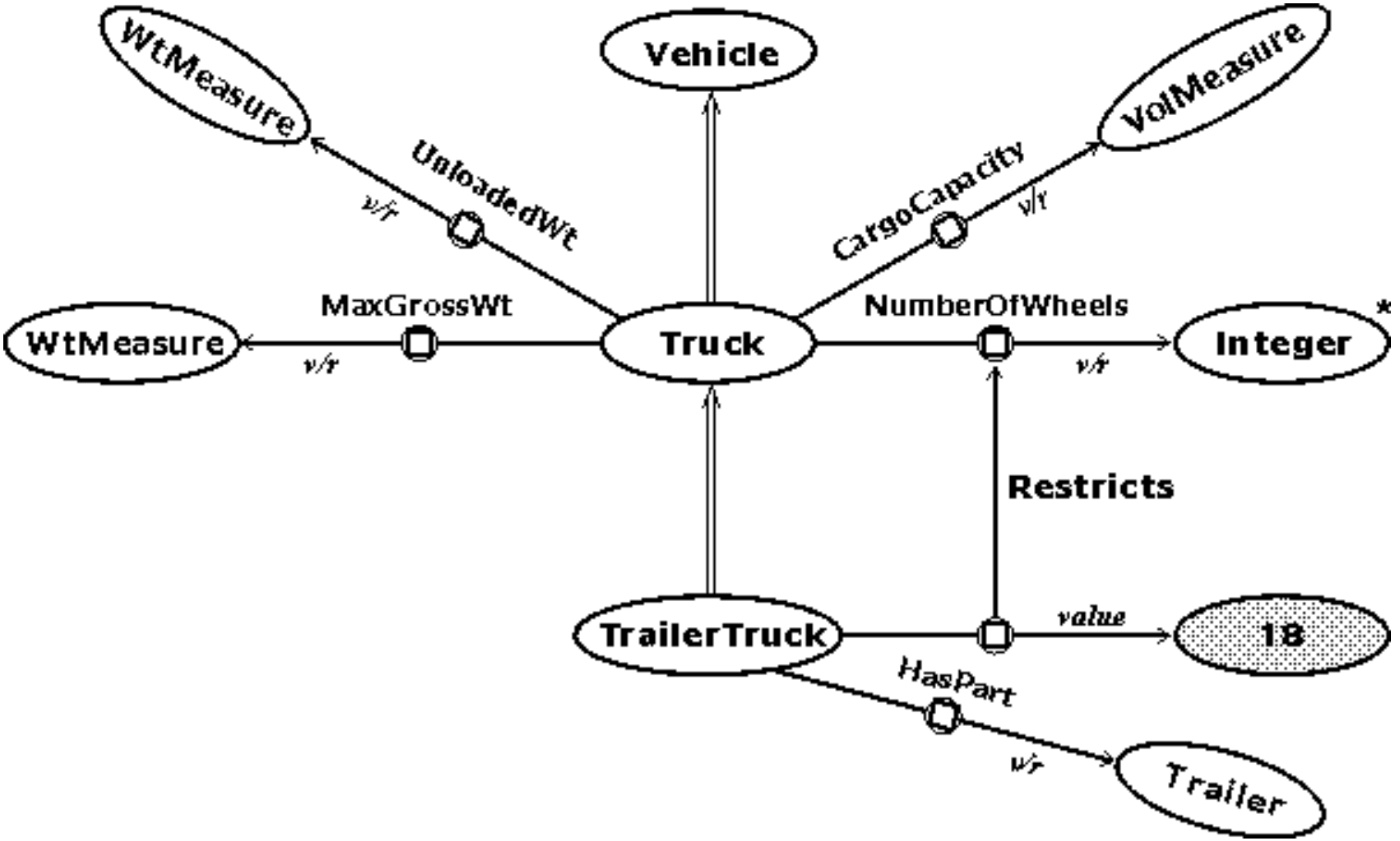
Semantic Networks (Collins & Quillian, 1967)



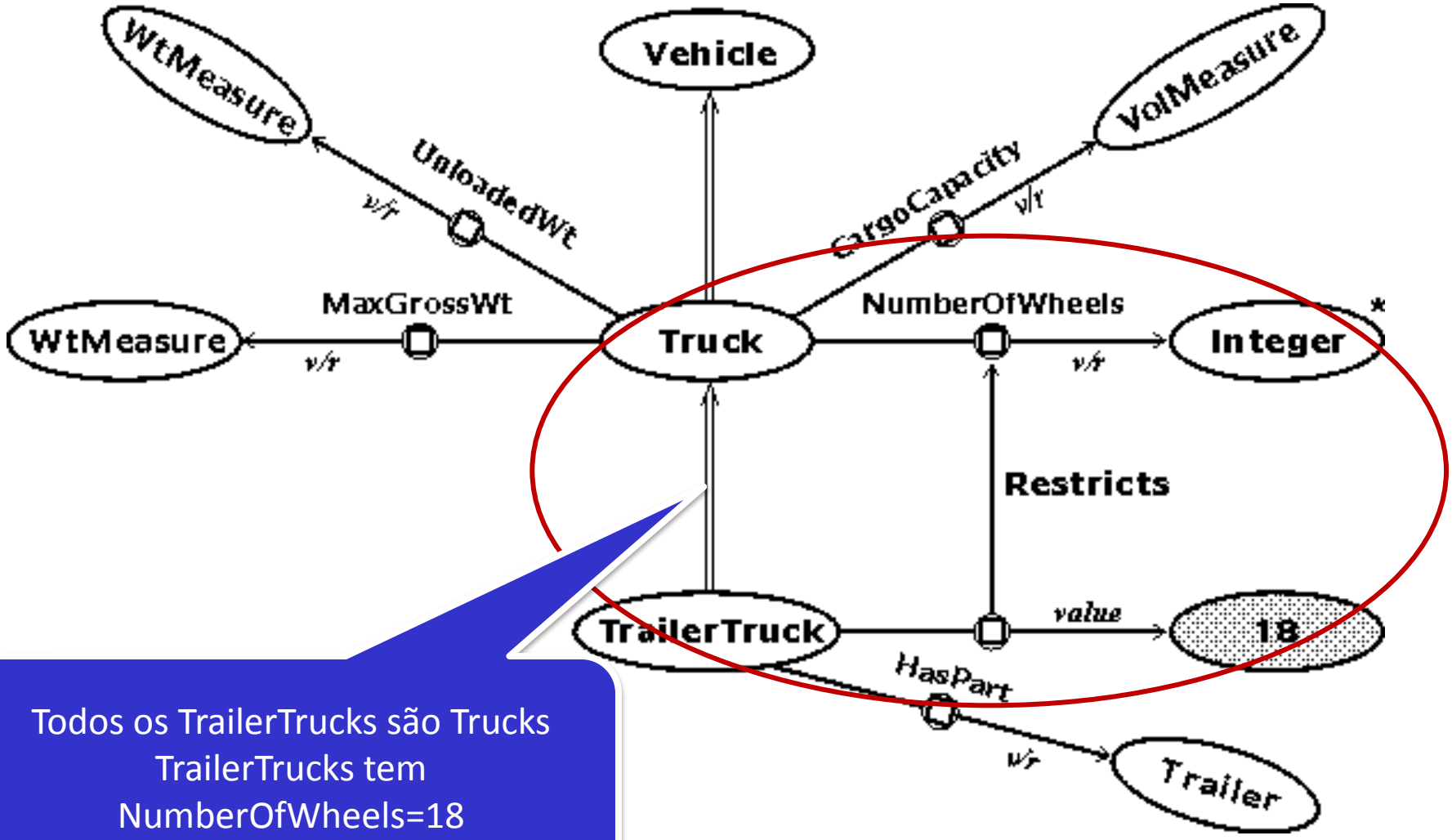
Semantic Networks (Collins & Quillian, 1967)



KL-ONE (Brachman, 1979)



KL-ONE (Brachman, 1979)

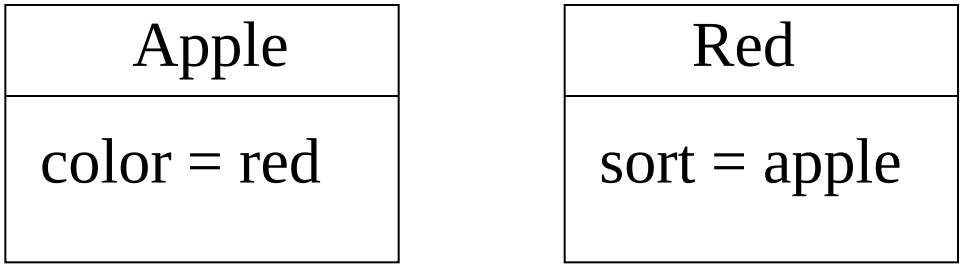


Todos os TrailerTrucks são Trucks
TrailerTrucks tem NumberOfWheels=18

The Logical Level

$\exists x\ \text{Apple}(x) \wedge \text{Red}(x)$

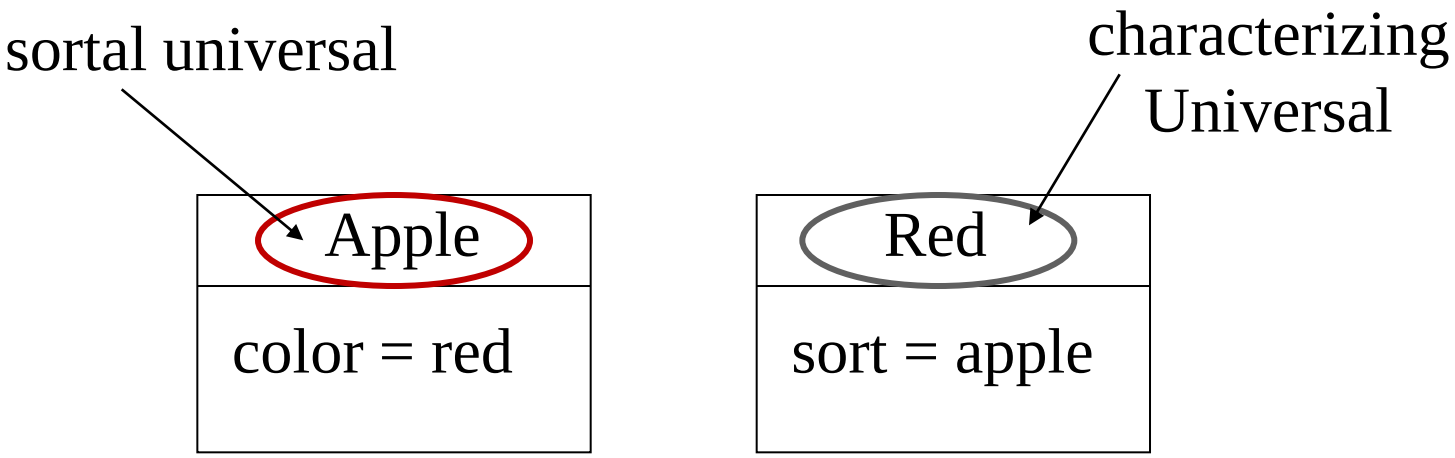
The Epistemological Level



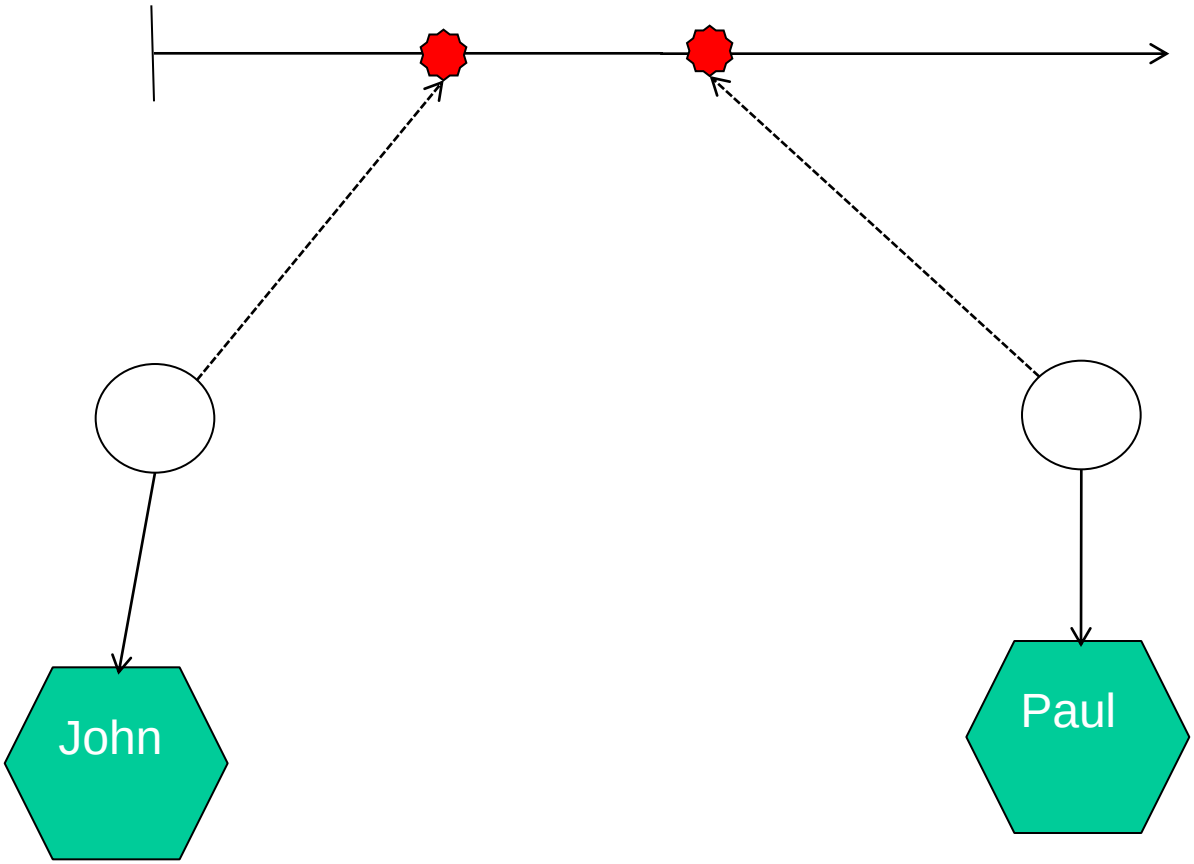
The Epistemological Level

Apple	Red
color = red	sort = apple

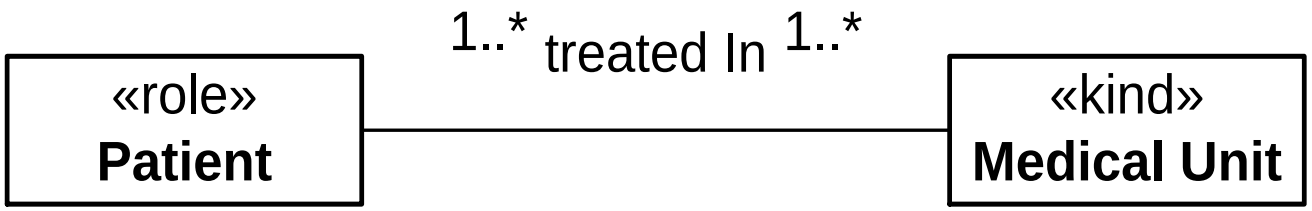
The Ontological Level



Formal Relations



Material Relations

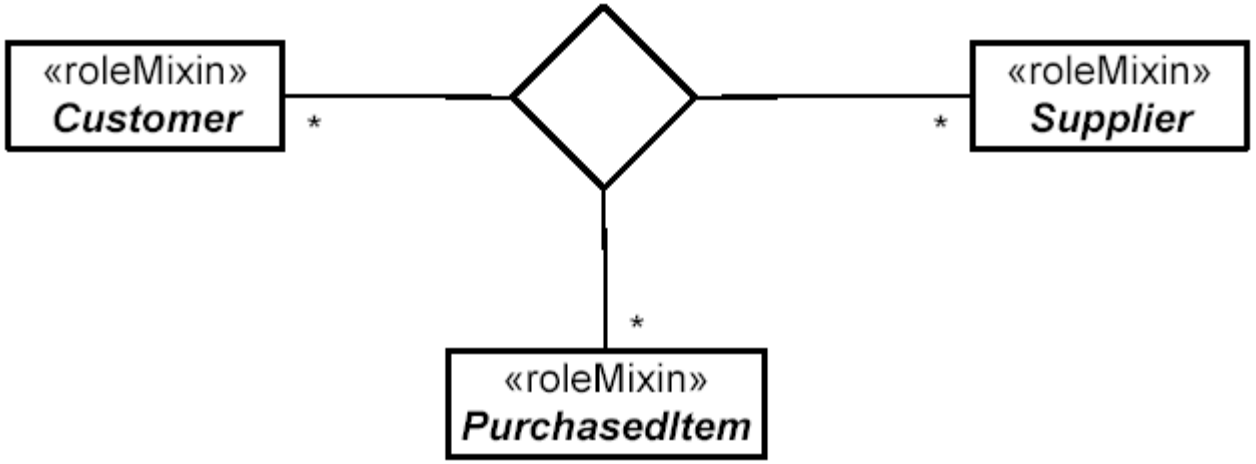


Material Relations

How are these cardinality constraints to be interpreted ?

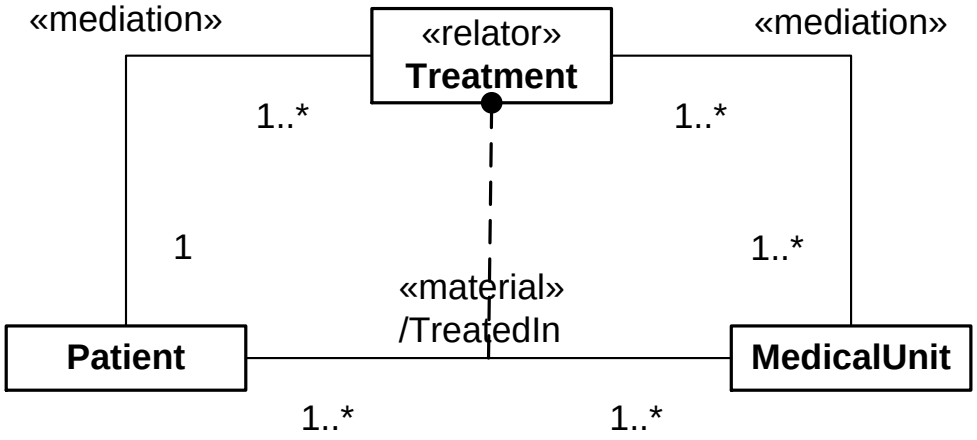
- In a treatment, a patient is treated by several medical units, and a patient can participate in many treatments
- In a treatment, a patient is treated by several medical units, but a patient can only participate in one treatment
- In a treatment, several patients can be treated by one medical unit, and a medical unit can participate in many treatments
- In a treatment, a patient is treated by one medical unit, and a patient can participate in many treatments
- ...

The problem is even worse in n-ary associations (with n > 2)



- In a given purchase, a Customer participates by buying many items from many Suppliers and a customer can participate in several purchases;
- In a given purchase, many Customers participate by buying many items from many Suppliers, and a customer can participate in only one purchase;
- In given purchase, a Customer participates by buying many items from a Supplier, and a customer can participate in several purchases;
- In given purchase, many Customers participate by buying many items from a Supplier, and a customer can participate in several purchases;

Explicit Representation for Material Relations



Material Relations

As seen before from a relator and mediation relation we can derive several material relations

Asides from all the benefits previously mentioned, perhaps the most important contribution of explicitly considering relations is to force the modeler to answer the fundamental question of what is *truthmaker* of that relation

Material Relations

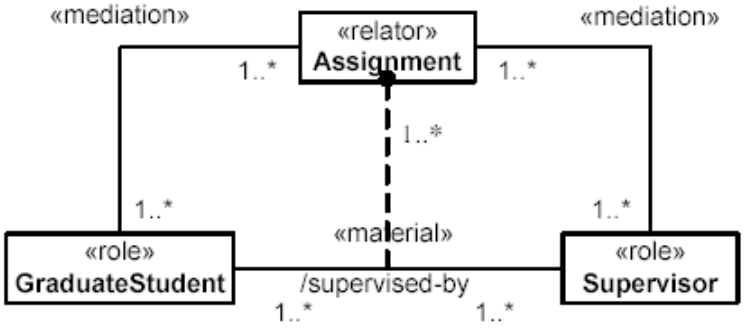
Yet another example:

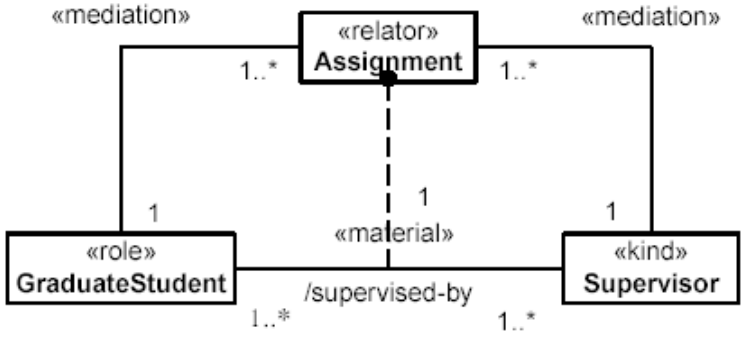
Modeling that a graduate student have one or more supervisors and a supervisor can supervise one or more students

Material Relations

Yet another example:

Modeling that a graduate student have one or more supervisors and a supervisor can supervise one or more students





ONTOLOGICAL FOUNDATIONS FOR STRUCTURAL CONCEPTUAL MODELS

GIANCARLO GUIZZARDI

Relevant Reference

Guizzardi, G. “Ontological Foundations for Structural Conceptual Models”, Telematica Instituut Fundamental Research Series No. 15,ISBN 90-75176-81-3 ISSN 1388-1795, The Netherlands, 2005.

Guarino, N.; Guizzardi, G., “In the Defense of Ontological Foundations for Conceptual Modeling”,Scandinavian Journal of Information Systems, Vol.18, No. 1, ISSN 0905-0167, 2006.

Guizzardi, G., Wagner, G. “Using the Unified Foundational Ontology (UFO) as a Foundation for General Conceptual Modeling Languages “,In: Theory and Application of Ontologies ed.Berlim: Springer-Verlag, 2010.

Unified Foundational Ontology (UFO)

UFO-C (SOCIAL ASPECTS)
(Agents, Intentional States, Goals, Actions,
Norms, Social Commitments/Claims, Social Dependency Relations…)

UFO-A (STRUCTURAL ASPECTS)
(Objects, their types, their parts/wholes,
the roles they play,
their intrinsic and relational properties
Property value spaces…)

UFO-B (DYNAMIC ASPECTS)
(Events and their parts,
Relations between events,
Object participation in events,
Temporal properties of entities, Time…)

Events

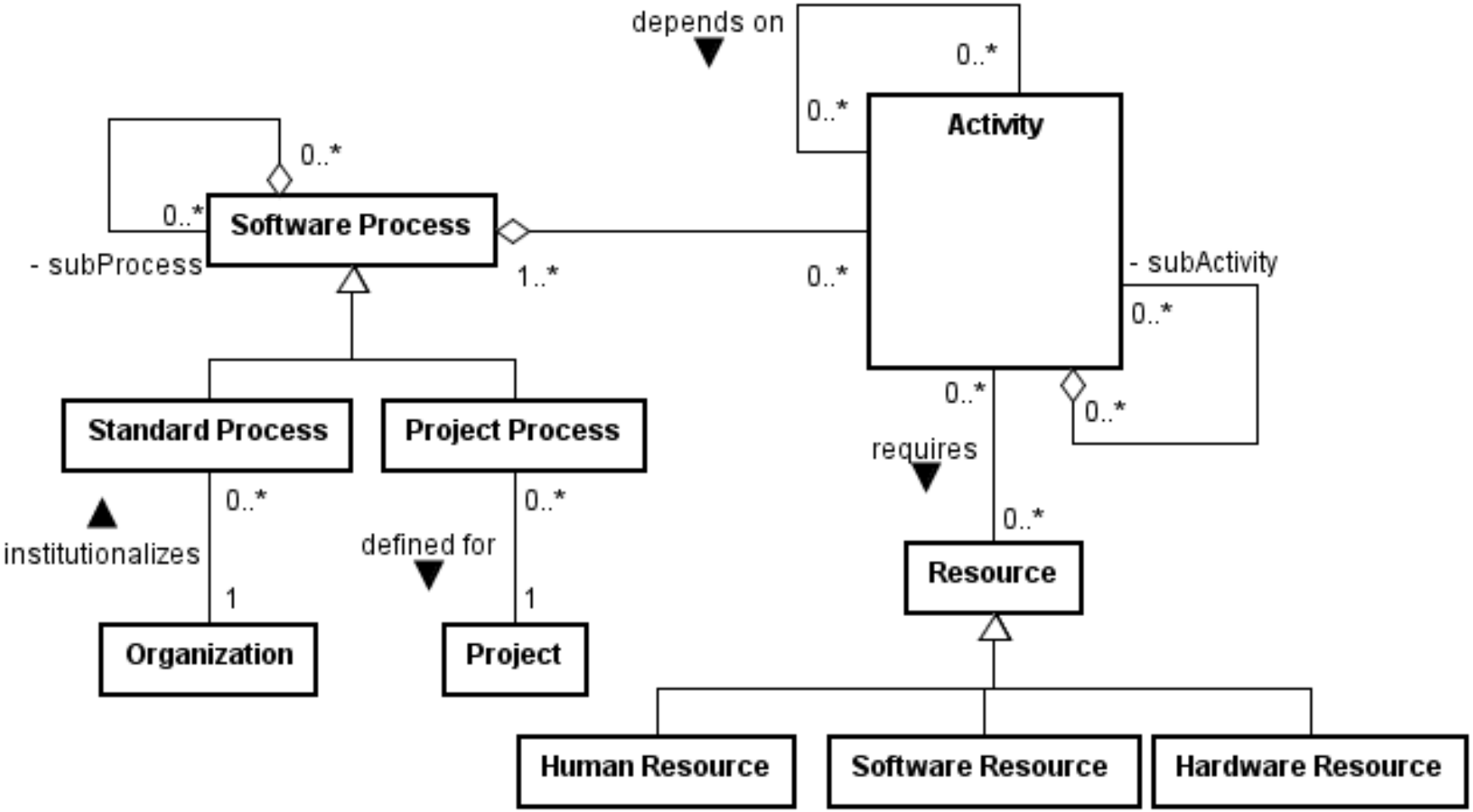
Events have a compositional structure

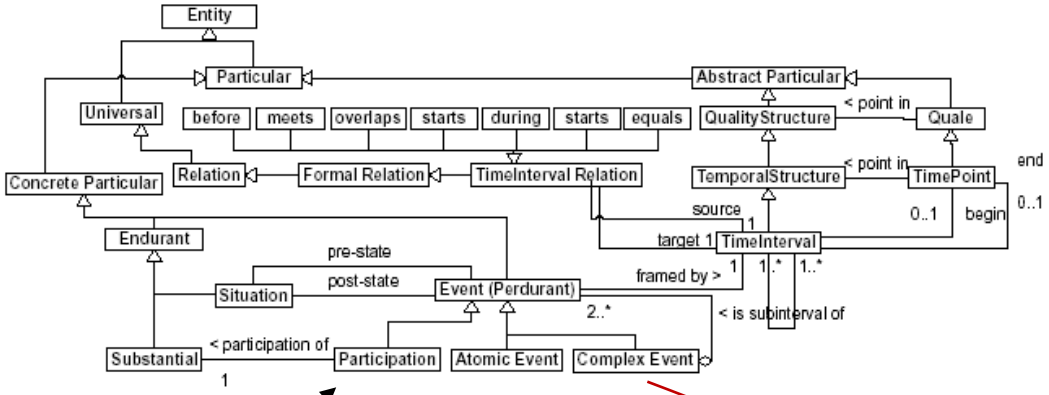
Events are dependent entities (participations)

Events can bear properties

Events are temporally connected

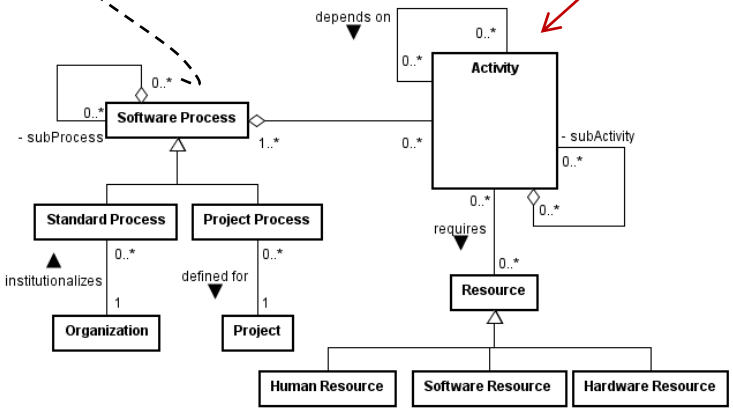
Events change the world (events map situations to situations)

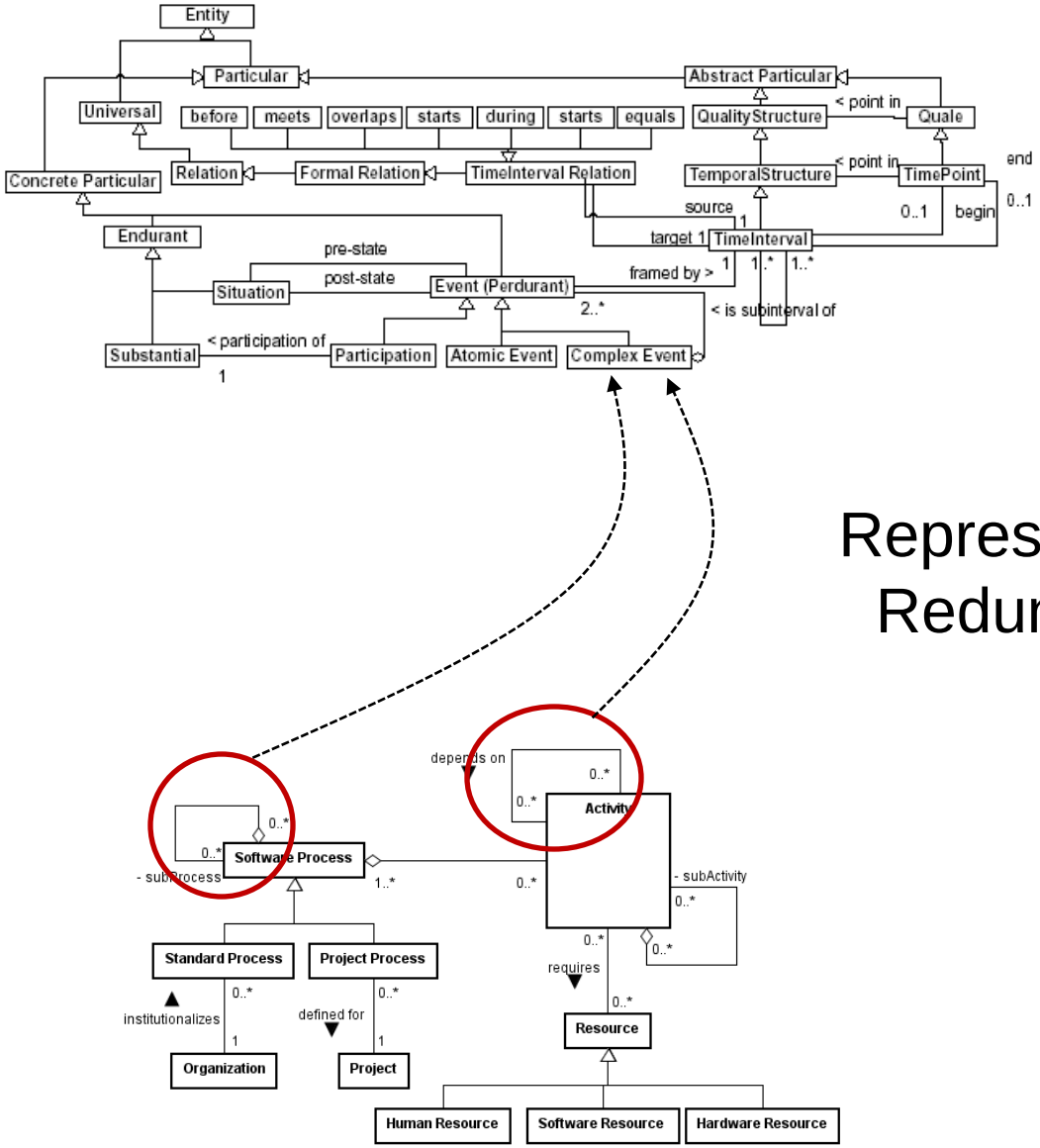

depends on
0..*
0..*
Activity
0..*
Software Process
- subProcess
1..*
0..*
- subActivity
0..*
0..*
0..*
Standard Process
Project Process
requires
0..*
institutionalizes
0..*
defined for
0..*
1
1
Resource
Organization
Project
Human Resource
Software Resource
Hardware Resource



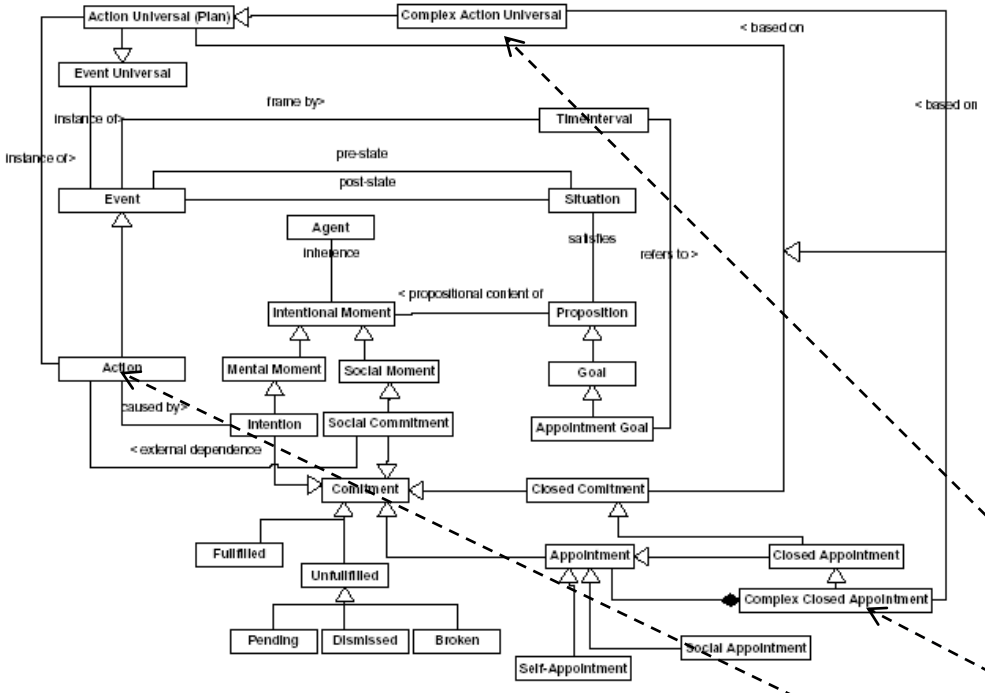
Ontological Grounding

Meta-Category Instantiation

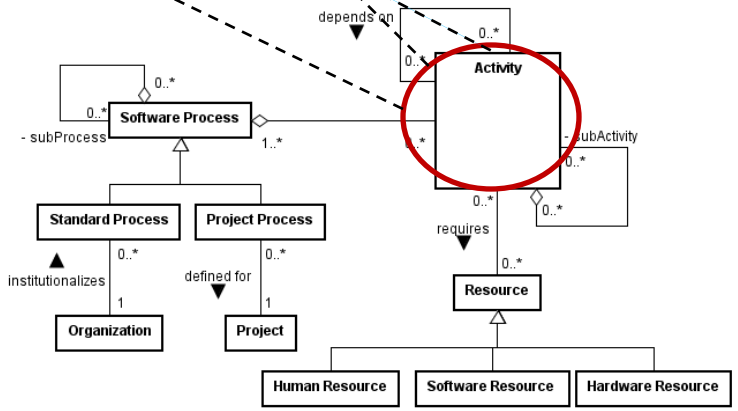


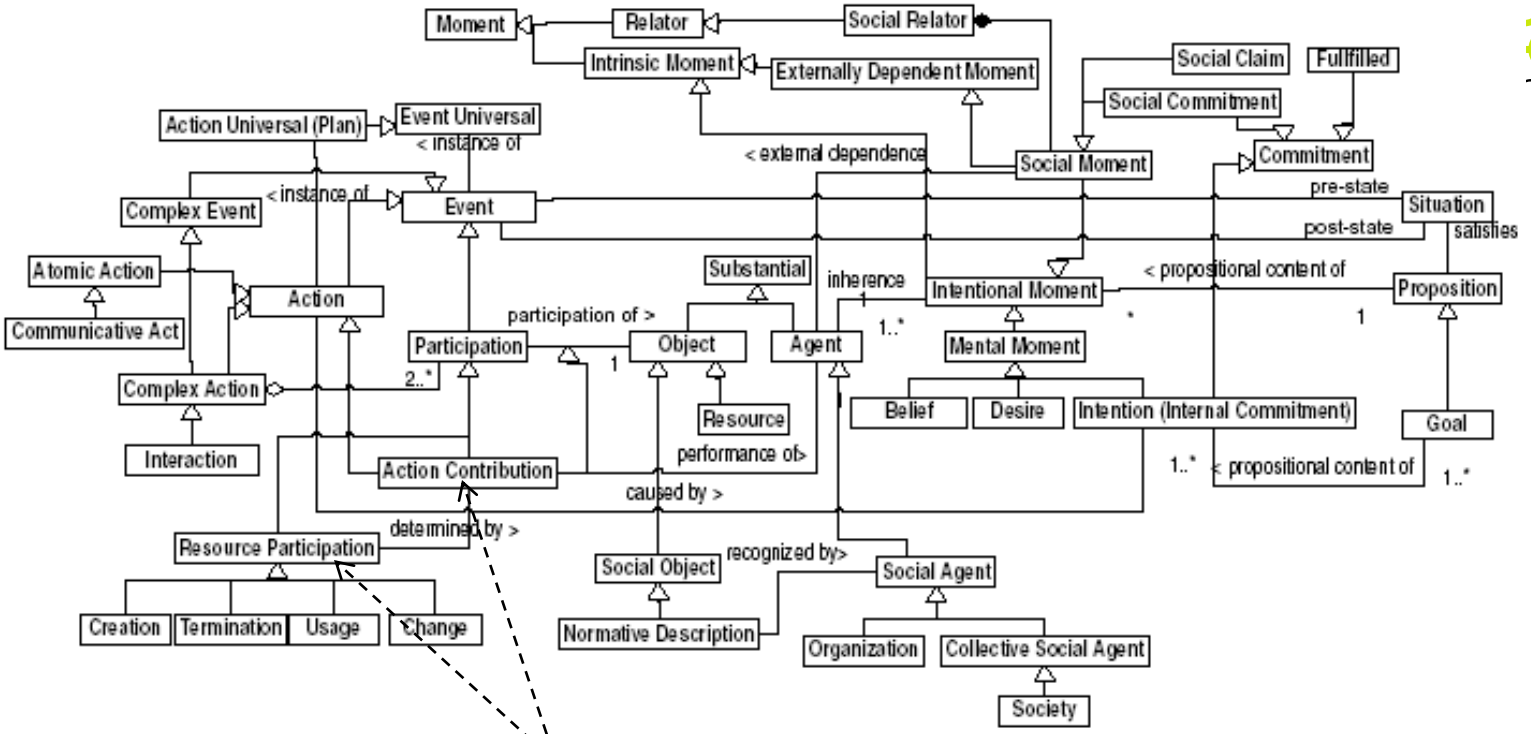


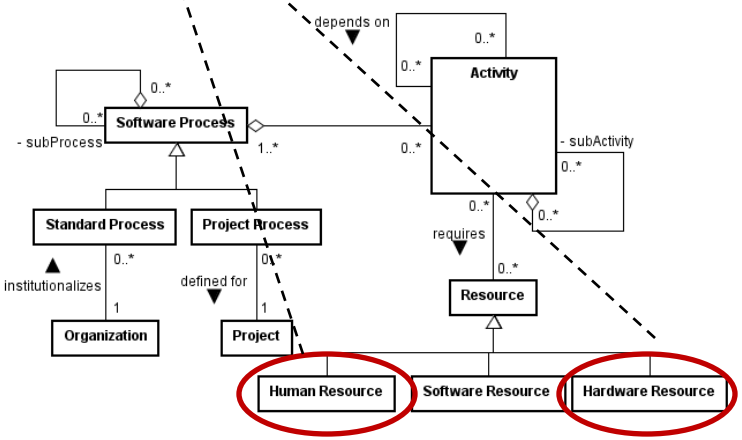
Representation Redundancy



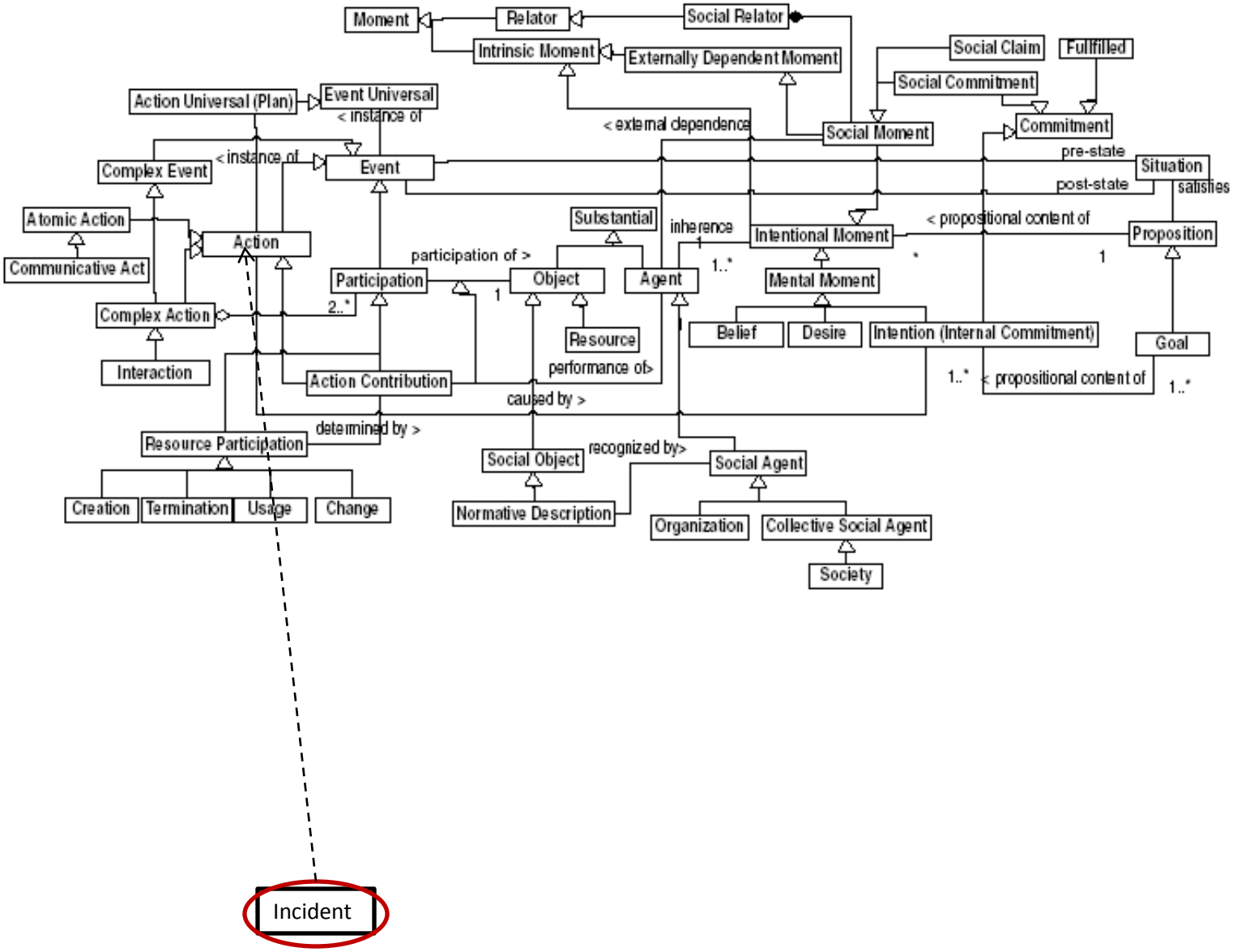
Categorical Overload







Undetected Logical Inconsistency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Relator
Social Relator
Intrinsic Moment
Externally Dependent Moment
Social Claim
Fullfilled
Social Commitment
Action Universal (Plan)
Event Universal
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< external dependence
Social Moment
Commitment
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Situation
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satisfies
Atomic Action
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inherence
Intentional Moment
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Communicative Act
participation of >
Participation
Object
Agent
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Mental Moment
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2..*
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Complex Action
Resource
Belief
Desire
Intention (Internal Commitment)
Goal
Interaction
Action Contribution
performance of>
1..*
< propositional content of
1..*
caused by >
determined by >
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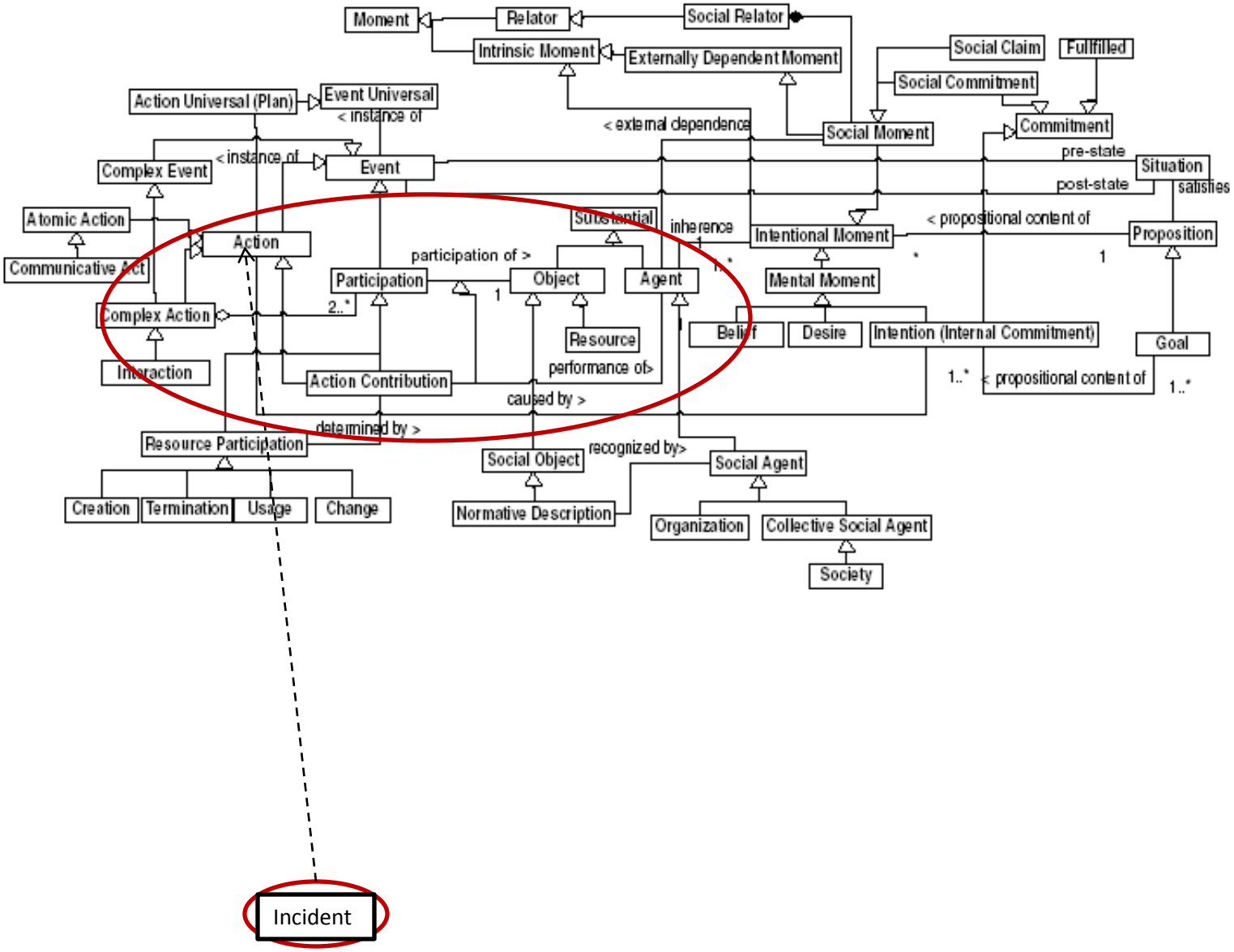
recognized by>
Social Object
Social Agent
Creation
Termination
Usage
Change
Normative Description
Organization
Collective Social Agent
Society
Incident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Social Relator
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Social Commitment
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pre-state
Situation
post-state
satisfies
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inherence
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Proposition
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participation of >
Communicative Act
Participation
Object
Agent
Mental Moment
2..*
1
Complex Action
Resource
Belief
Desire
Intention (Internal Commitment)
Goal
performance of>
Interaction
Action Contribution
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caused by >
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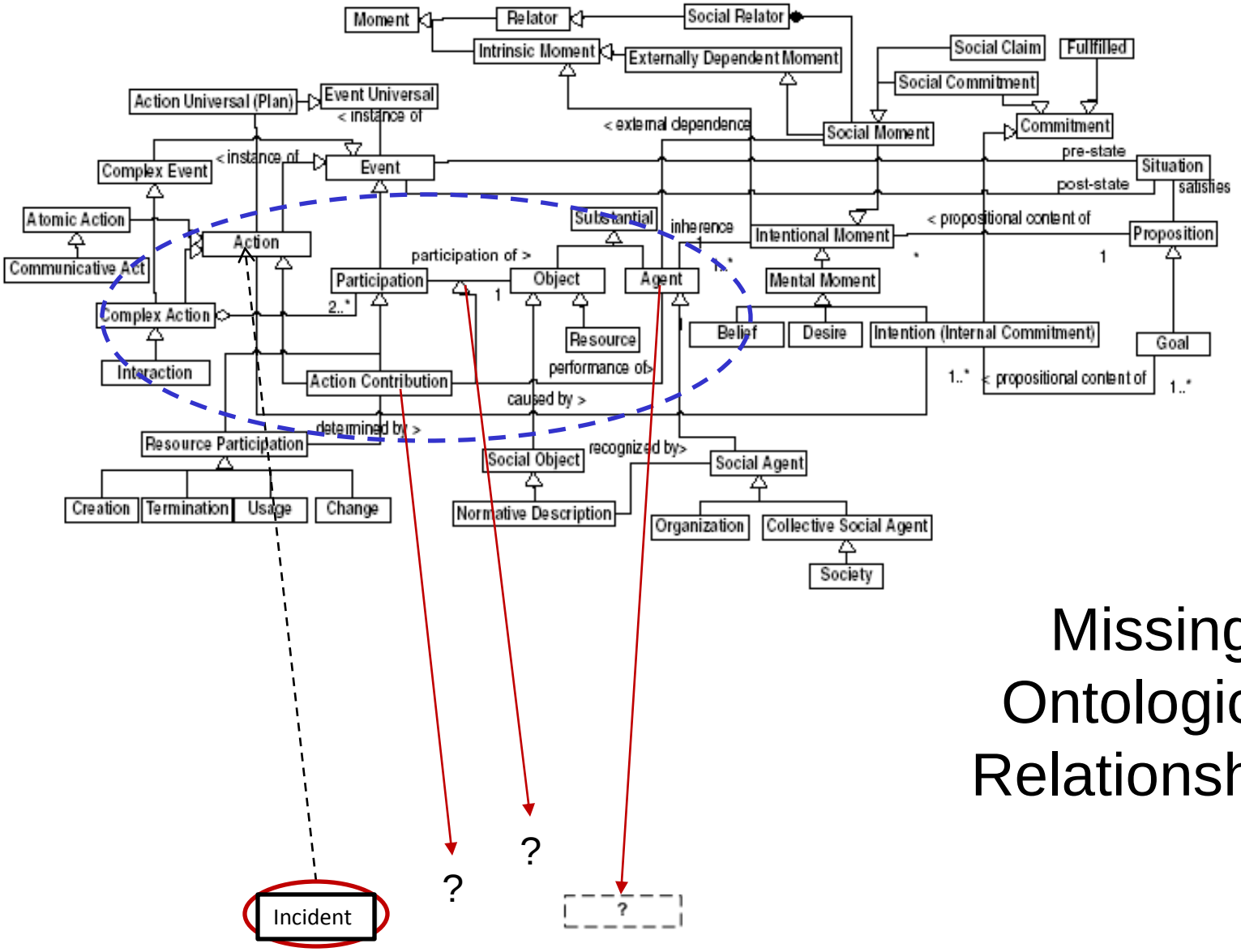
Incident



Missing Ontological Relationships

Prying Apart Semantics and Implementation

Generating XML Schemata directly from ontologically sound conceptual models

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System Engineer
U.S. Department of Defense
<btbauma@earthlink.net>

Abstract

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- Generalization
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Design
- Example
- Conclusion

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- Challenges
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How to cite this paper

Prying Apart Semantics and Implementation

Generating XML Schemata directly from ontologically sound conceptual models

Balisage: The Markup Conference 2009
August 11 - 14, 2009

Introduction

Schemata in the World Wide Web Consortium's (W3C) Extensible Markup Language (XML) Schema language (XSD), Relax Next Generation (RNG), Structured Query Language (SQL) Data Definition Language (DDL), Resource Description Framework Schema (RDFS), or Web Ontology Language (OWL)) are typically created directly. A basic text editor can be used, although more likely today it will be with a design tool that uses visual symbols with a more or less bijective mapping to the constructs in the chosen implementation language. Various profiles of the Unified Modeling Language (UML) class diagrams have been proposed as a visualization for XSD design Bernauer-2004; various forms of Entity Relationship Diagrams (ERD)'s are the preferred choice for relational database (SQL DDL) design. And then there are the numerous languages specific to a given vendors tool.

As useful as these visual design languages are, they are first, representations of a design in a specific implementation language, and only secondarily do they reflect the semantics of a Universe of Discourse (UoD) or domain.[1] Or as stated in the introduction to Guizzardi-2005 pages 7 - 8.

> Nowadays, many languages exist that are used for the purpose of creating representations of real-world conceptualizations. These languages are sometimes named domain modeling languages (e.g., LINGO), ontology representation languages (e.g., OWL), semantic data modeling languages (e.g., ER), among other terms. ... Although these languages are employed in practice for conceptual modeling, they are not designed with the specific purpose of being truthful to reality. For instance, LINGO (Falbo &

Relevant Reference

GUIZZARDI, G., FALBO, R. A., GUIZZARDI, R. S. S.

Grounding Software Domain Ontologies in the Unified Foundational Ontology (UFO): The case of the ODE Software Process Ontology (In: XI Iberoamerican Conference on Software Engineering (CIbSE'2008), 2008, Recife.

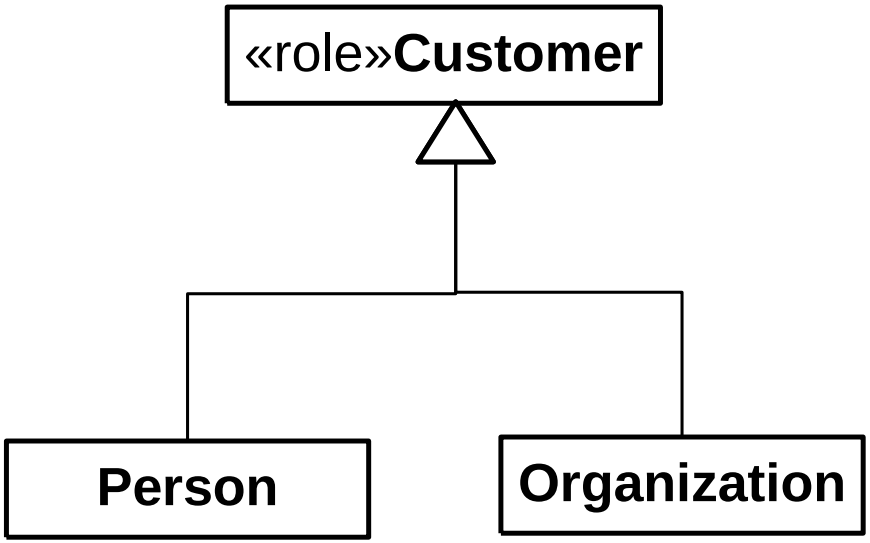
3. We need Patterns

- *Design Patterns*
- *Analysis Patterns*
- *Transformation Patterns*
- *Patterns Languages*

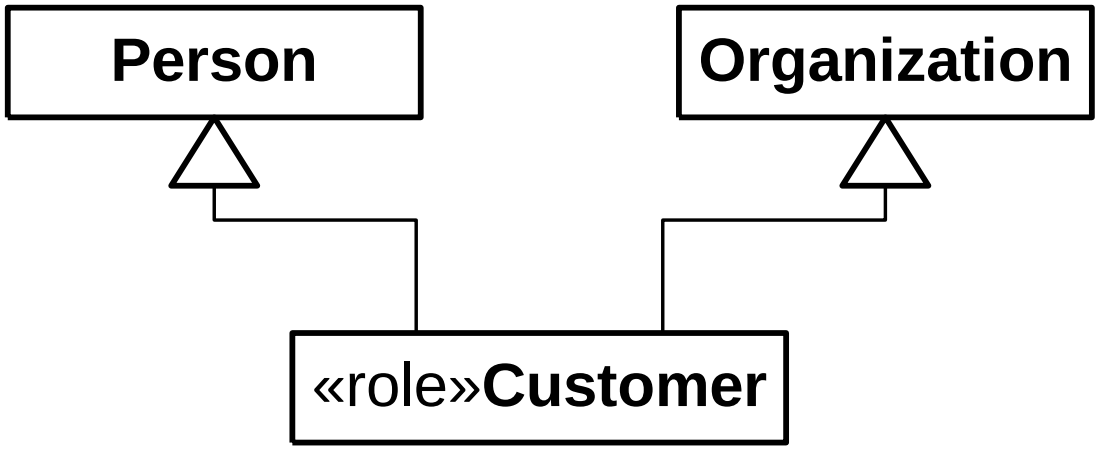
Recurrent Modeling Problems

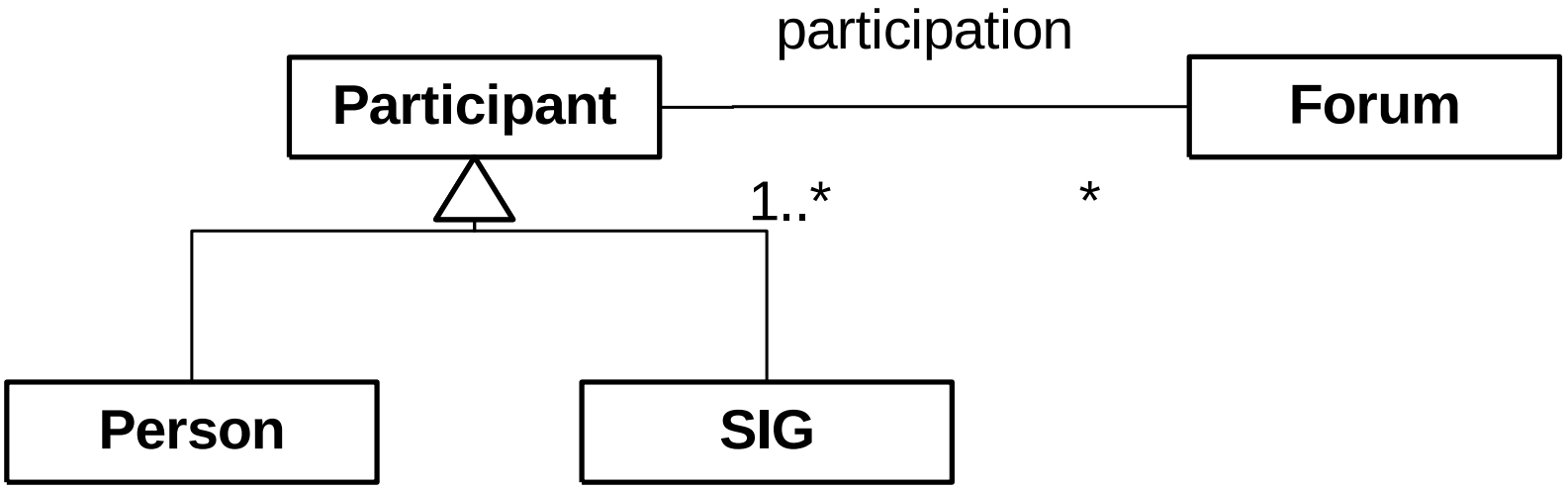
“how would one model the customer entity conceptually? The Customer as a supertype of Organisation and Person? The Customer as a subtype of Organisation and Person? The Customer as a relationship between or Organisation and (Organization or Person)?”

Roles with Disjoint Allowed Types



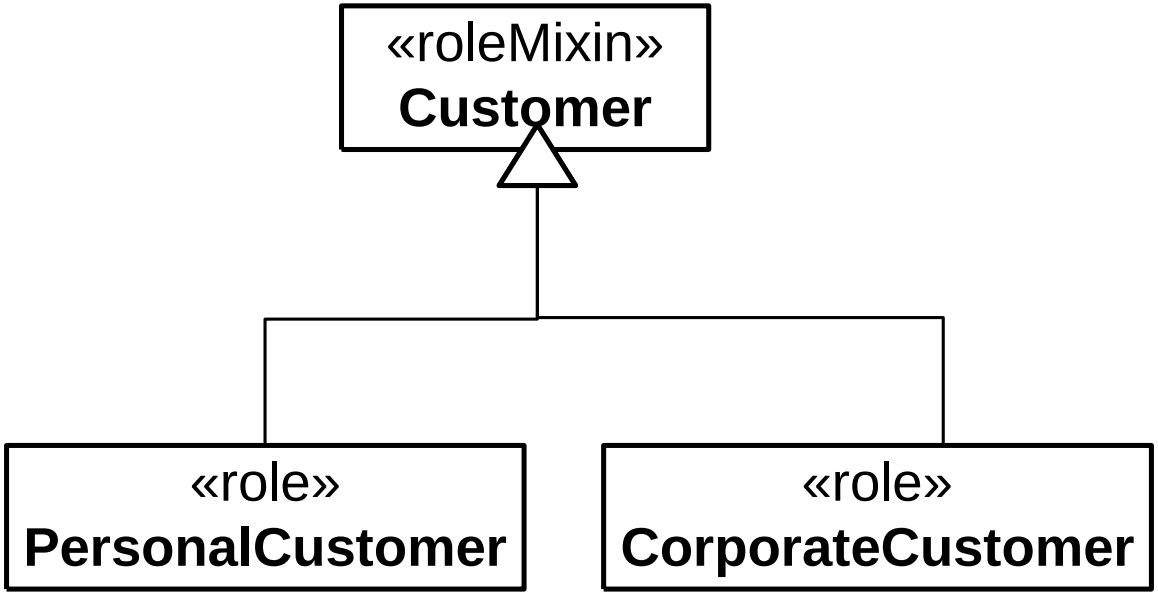
Roles with Disjoint Allowed Types



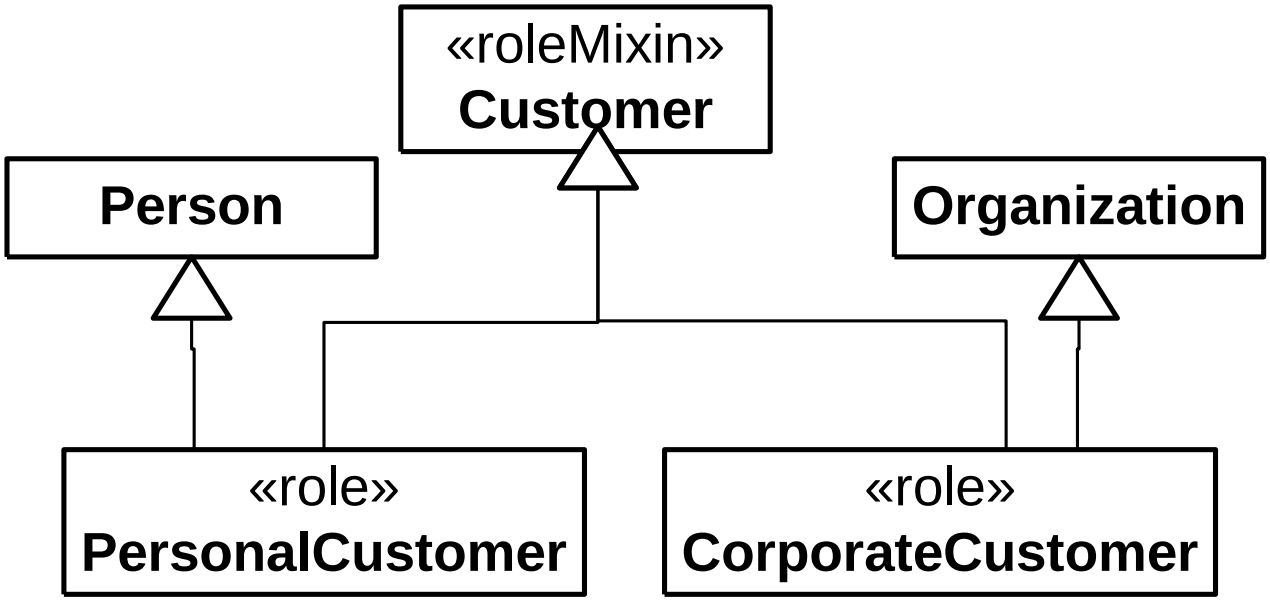

participation
Participant
Forum
1..*
*
Person
SIG

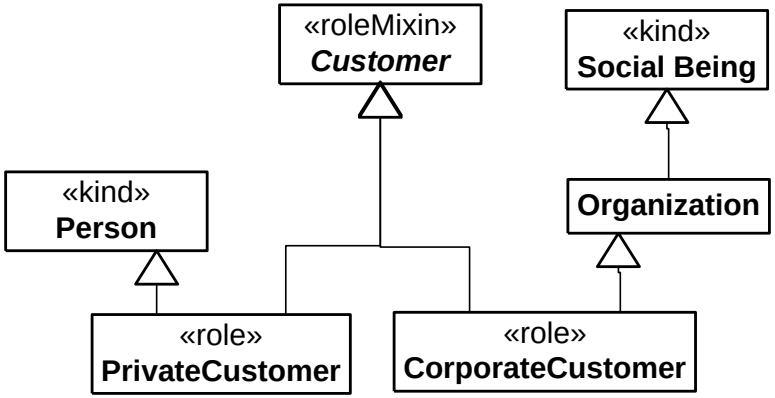
Roles with Disjoint Admissible Types

Roles with Disjoint Allowed Types



Roles with Disjoint Allowed Types

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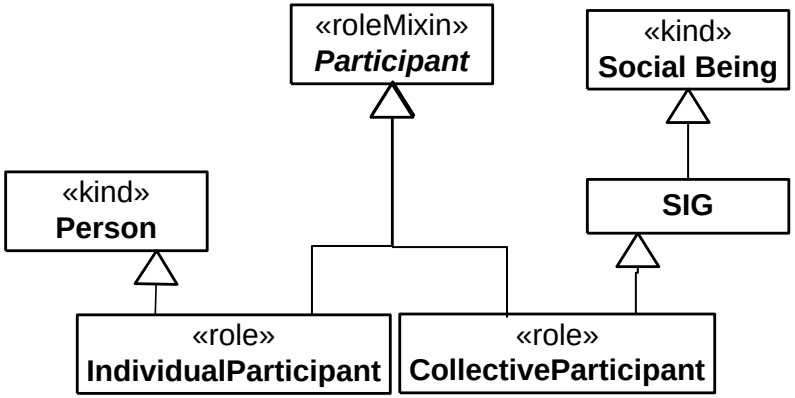
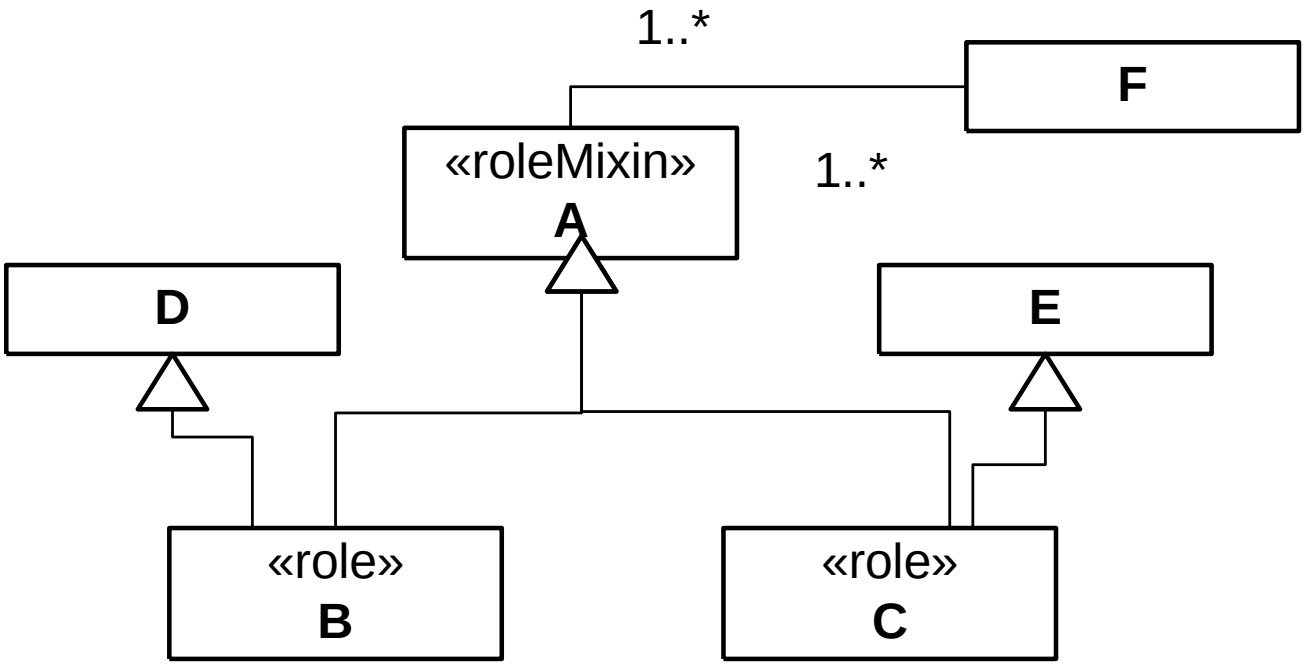
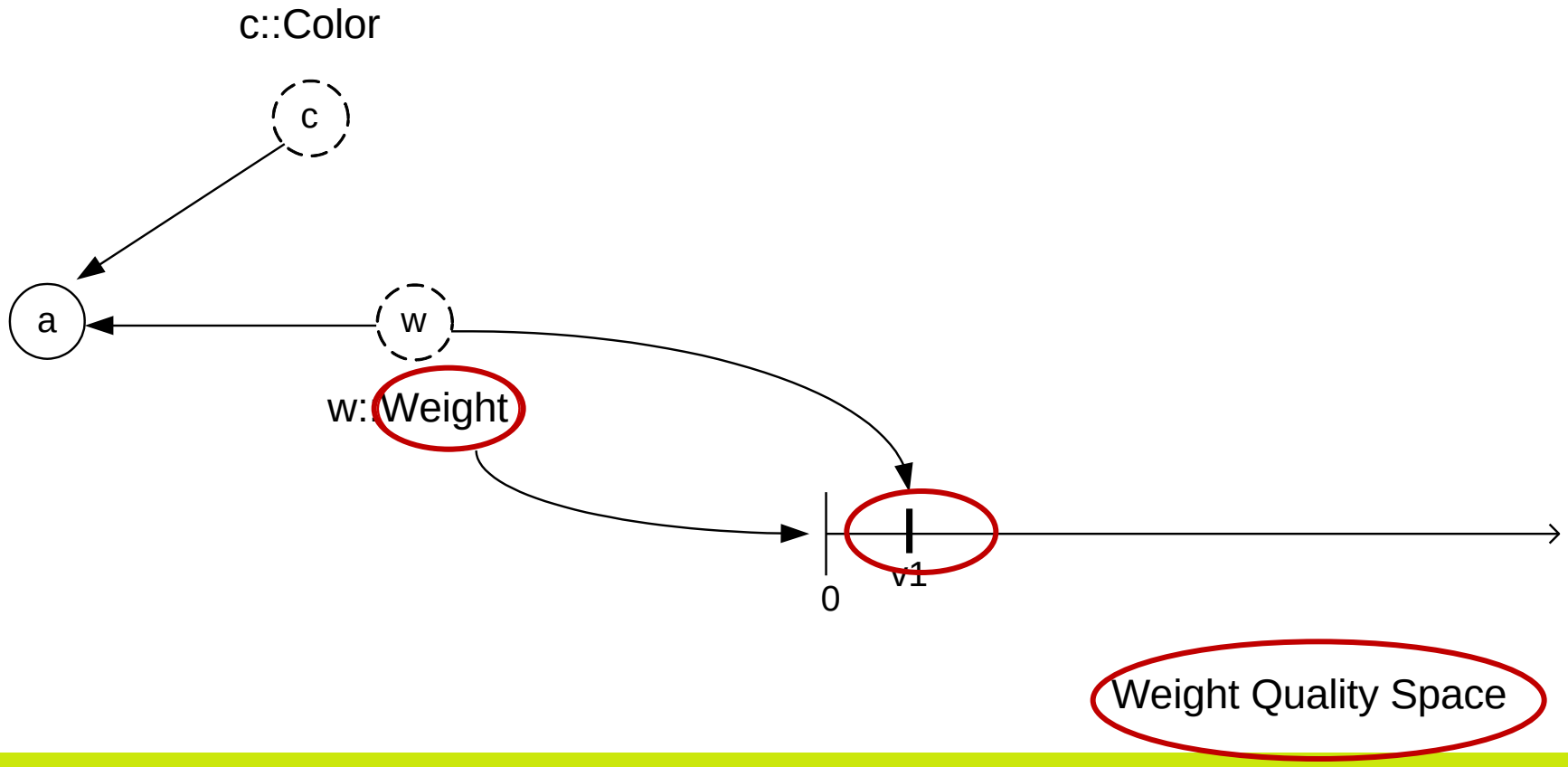
Social Being
«kind»
Person
Organization
«role»
PrivateCustomer
«role»
CorporateCustomer


«roleMixin»
Participant
«kind»
Social Being
«kind»
Person
SIG
«role»
IndividualParticipant
«role»
CollectiveParticipant

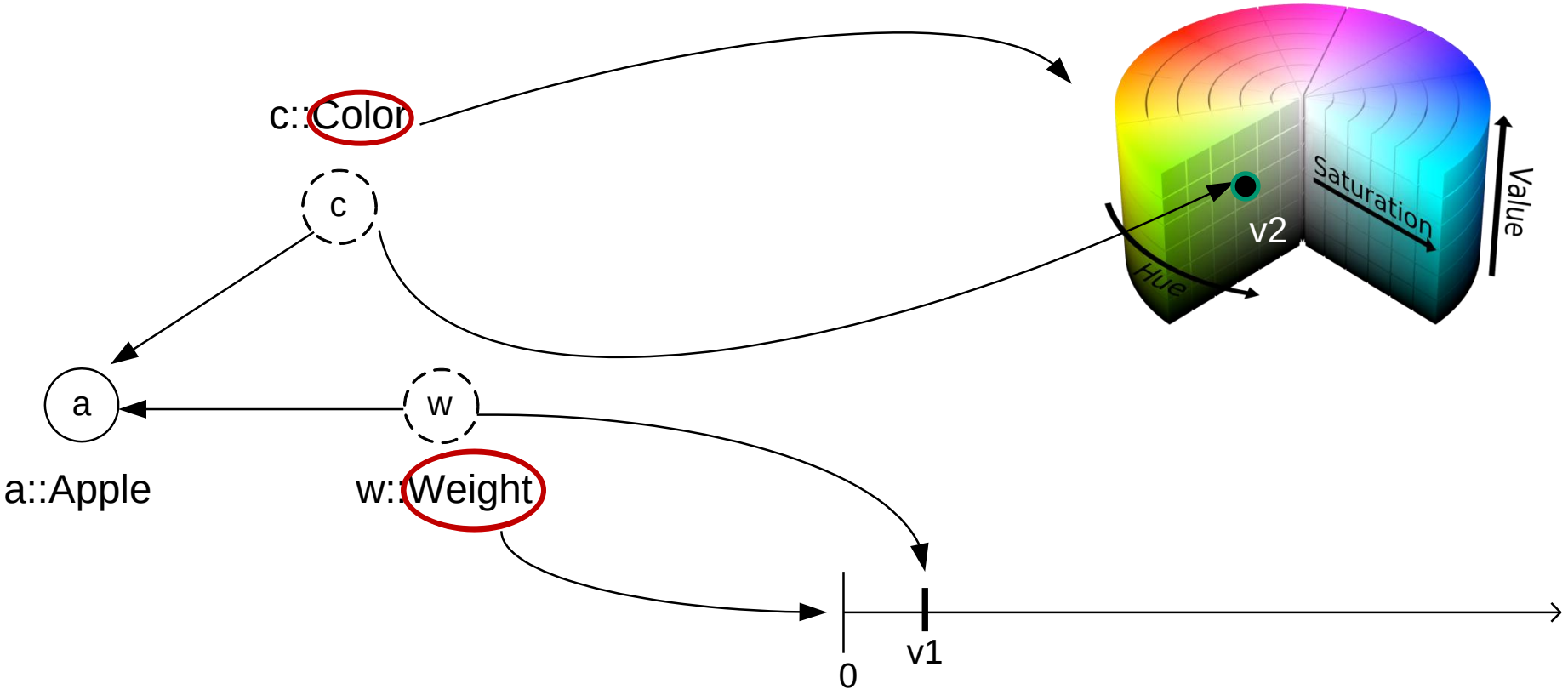
Roles with Disjoint Admissible Types



Quality, Quale, Quality Space

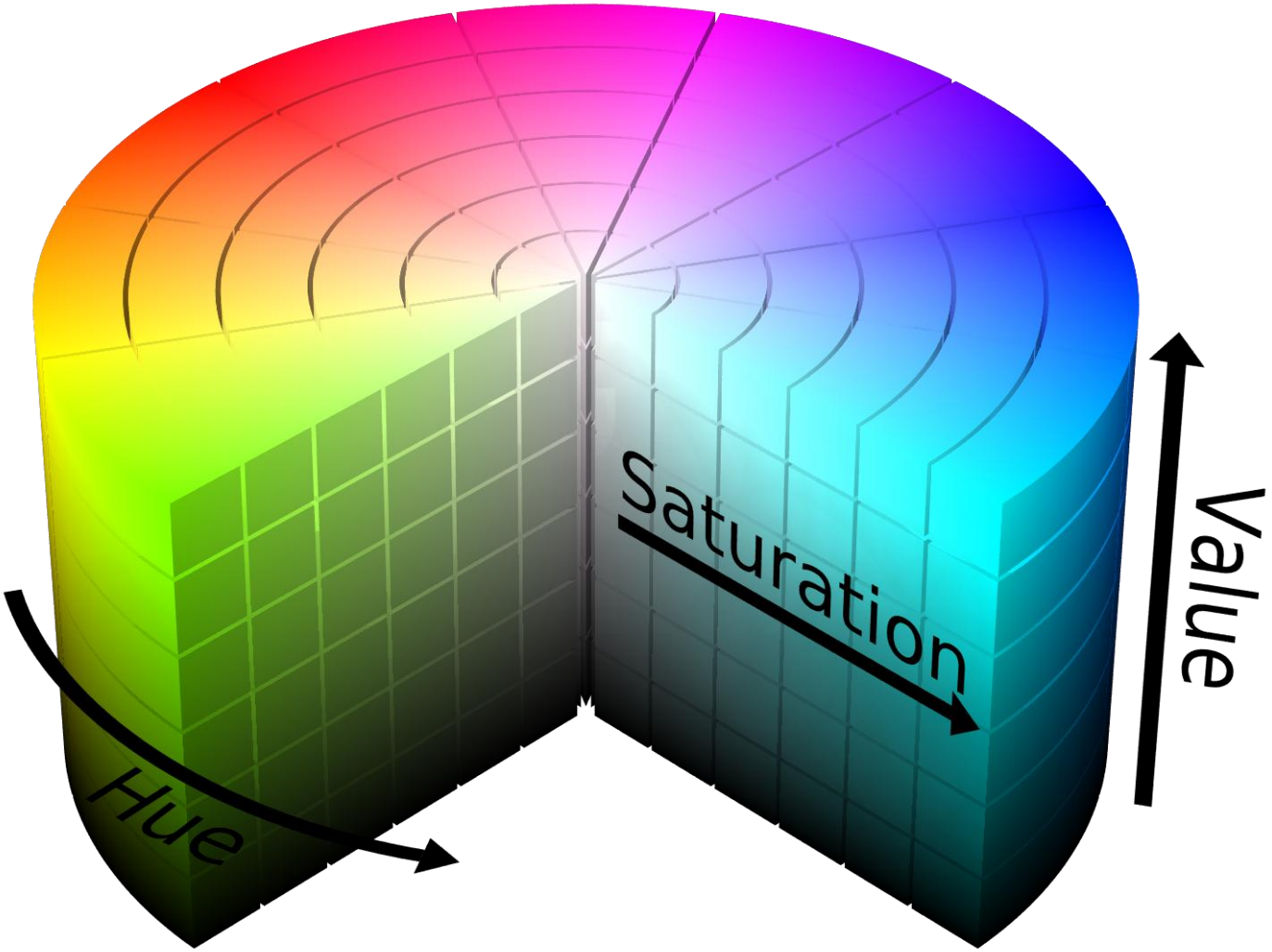


Quality, Quale, Quality Space



Weight Quality Space

Quality Space with Multiple Quality Dimensions



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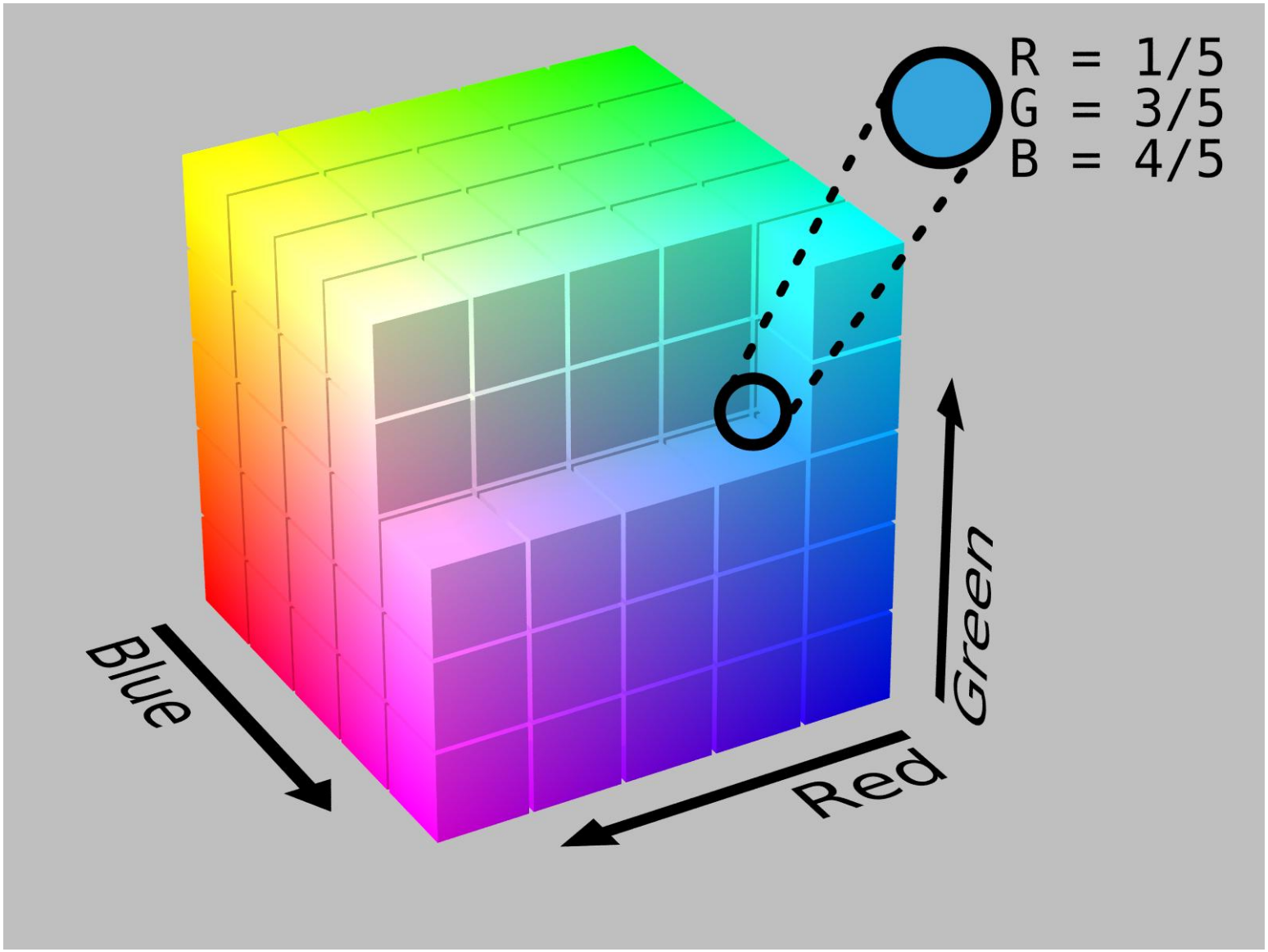
Quality Space with Multiple Quality Dimensions



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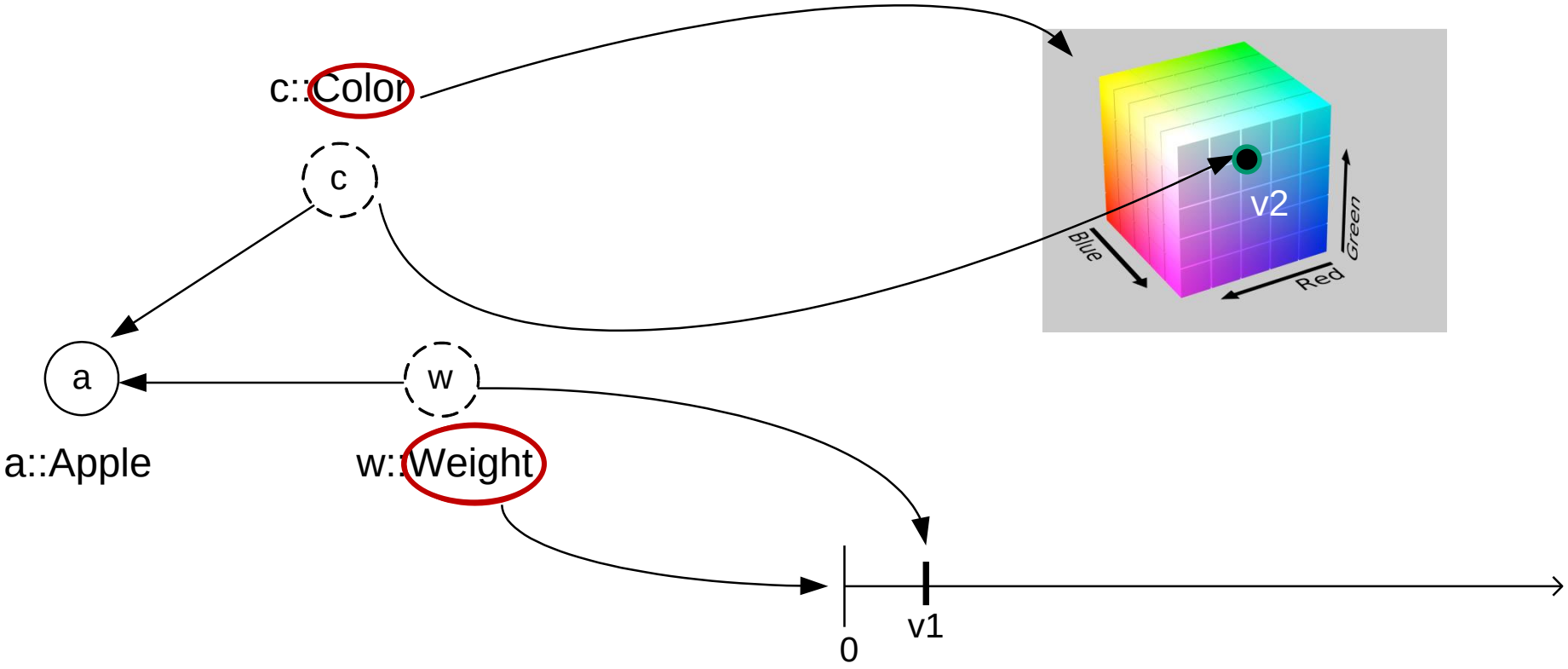
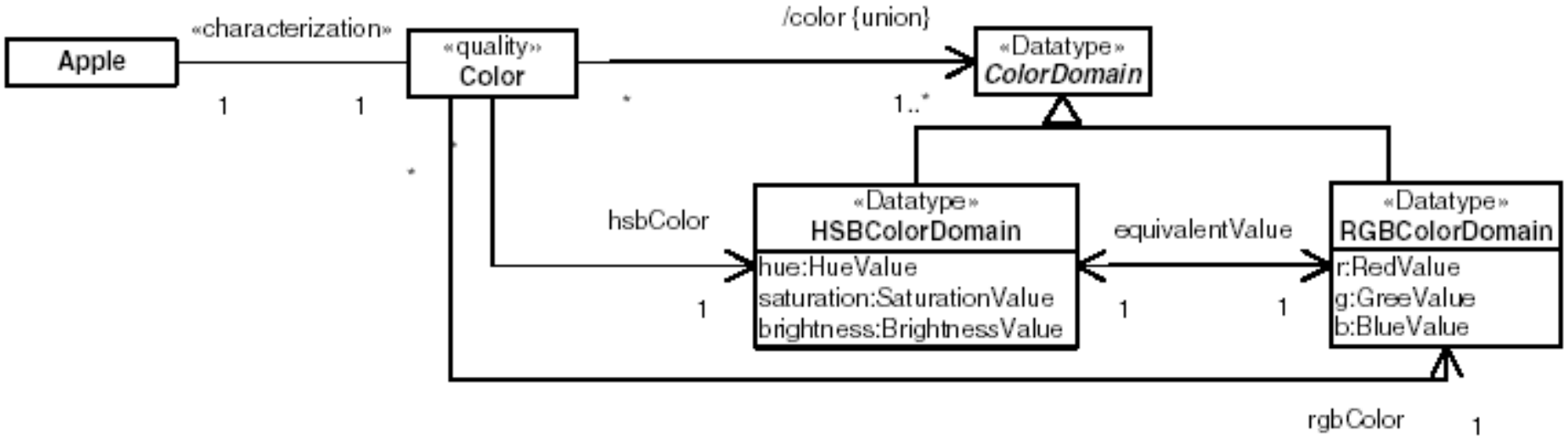
Alternative Quality Spaces

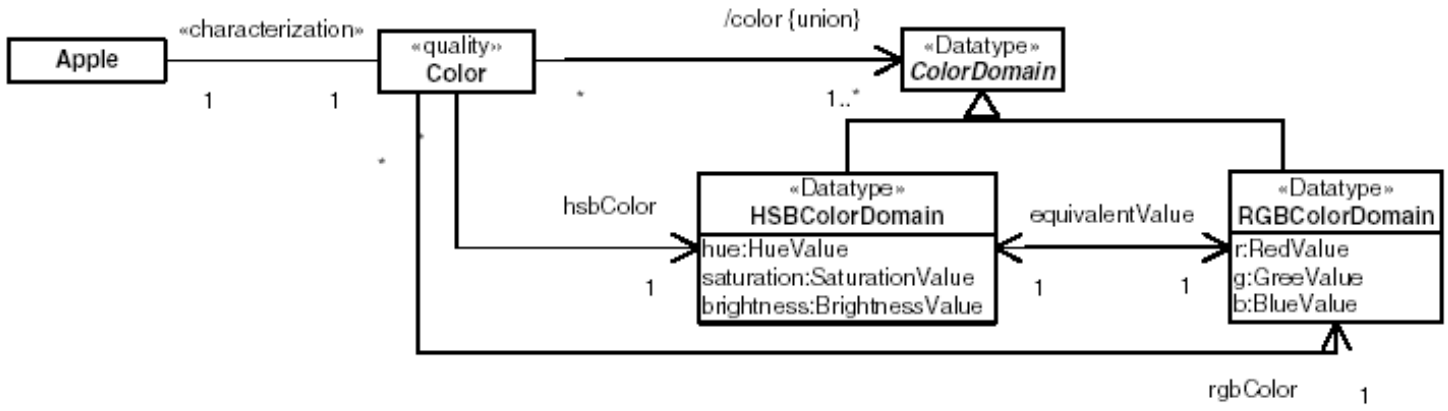


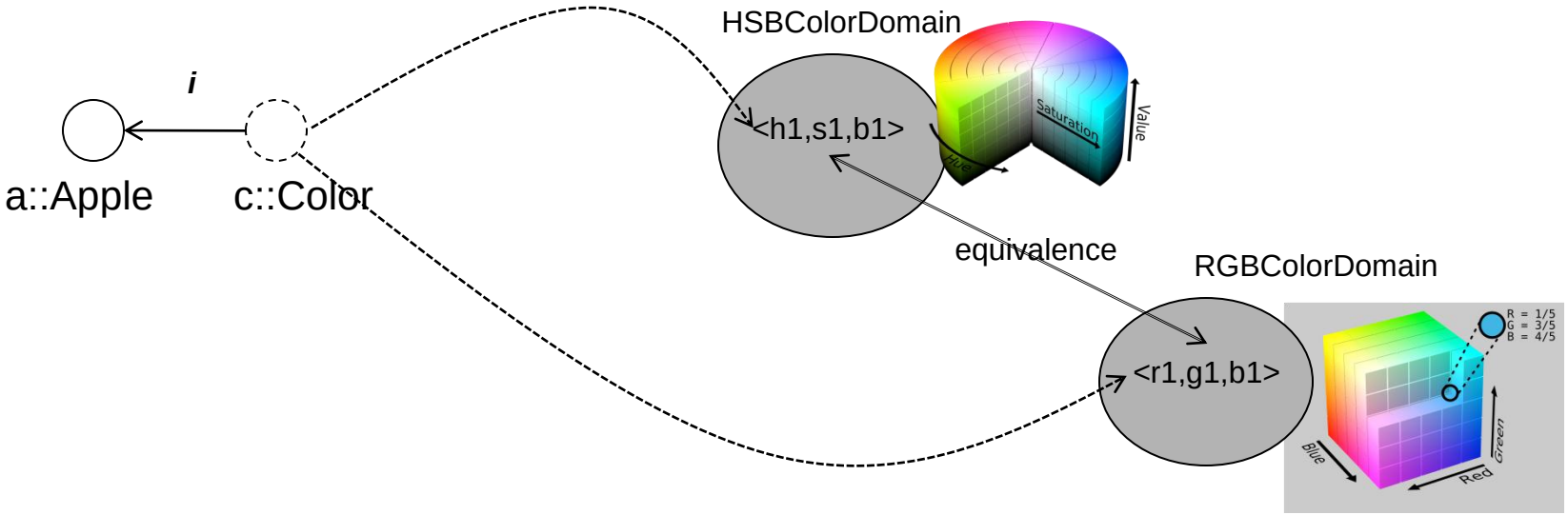
Weight Quality Space

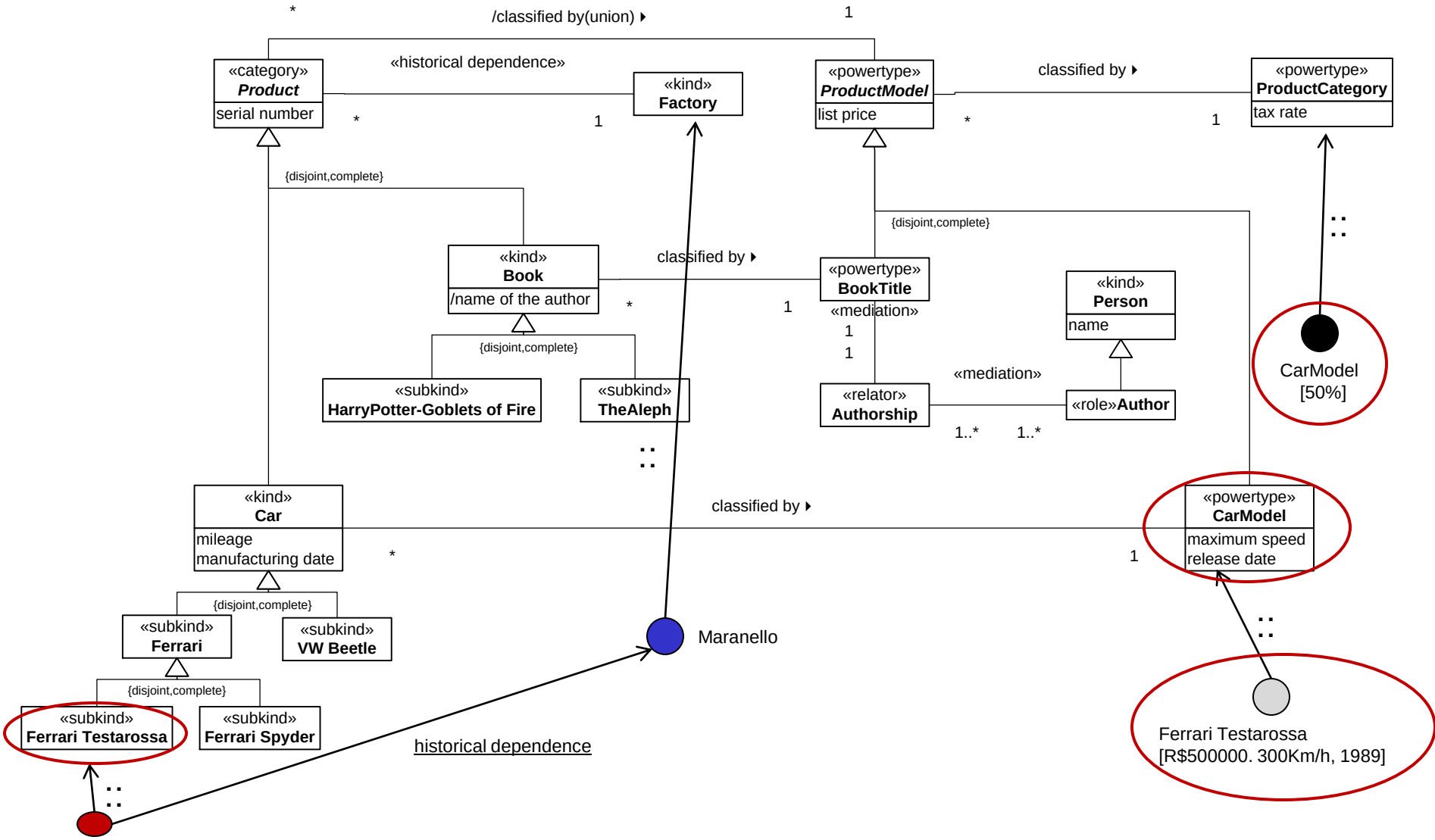
Explicit Representation of Qualities and Quality Spaces



Explicit Representation of Qualities and Quality Spaces



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Product
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ProductCategory
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*
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TheAleph
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Authorship
«role»Author
1..*
1..*
CarModel
[50%]
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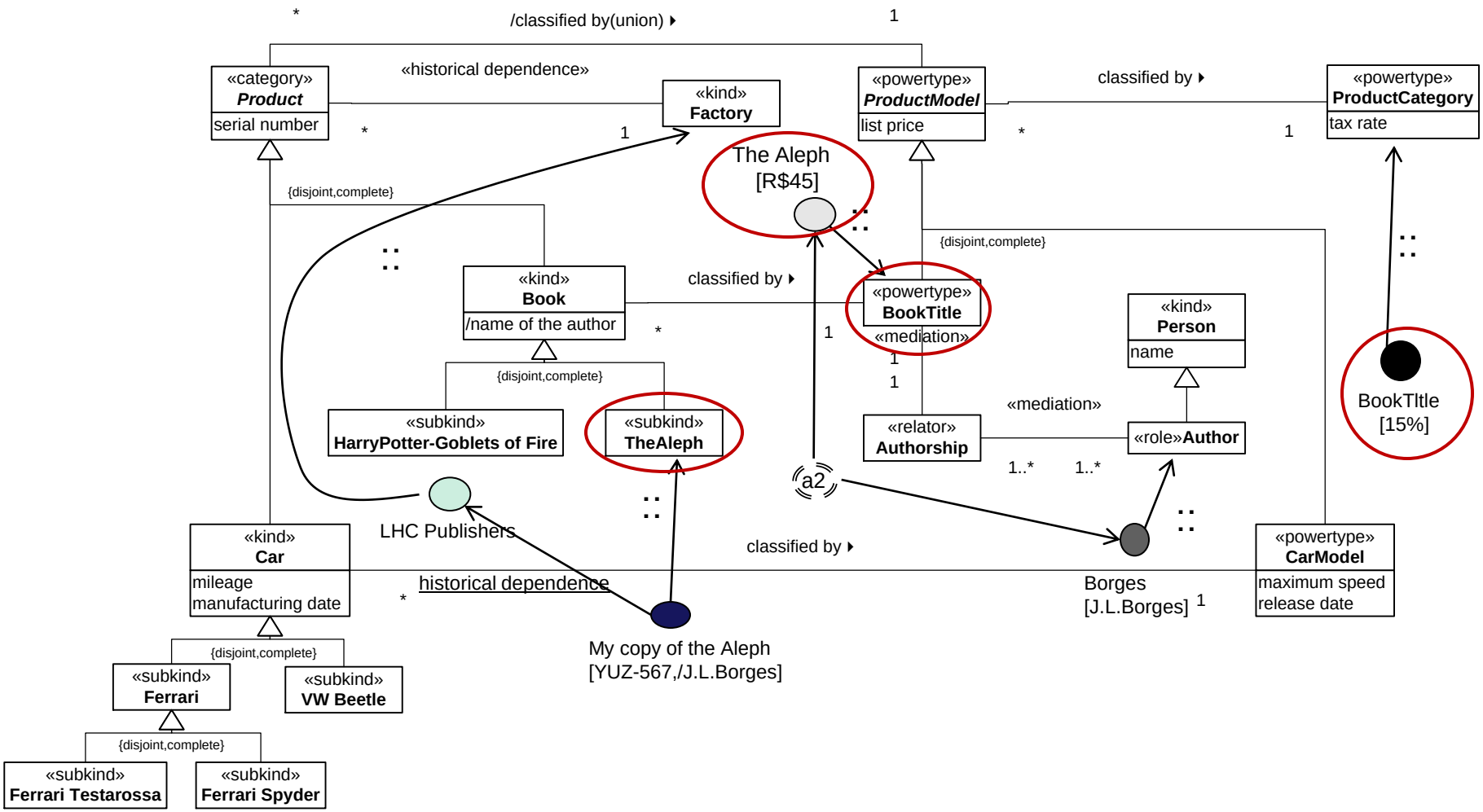
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release date
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historical dependence
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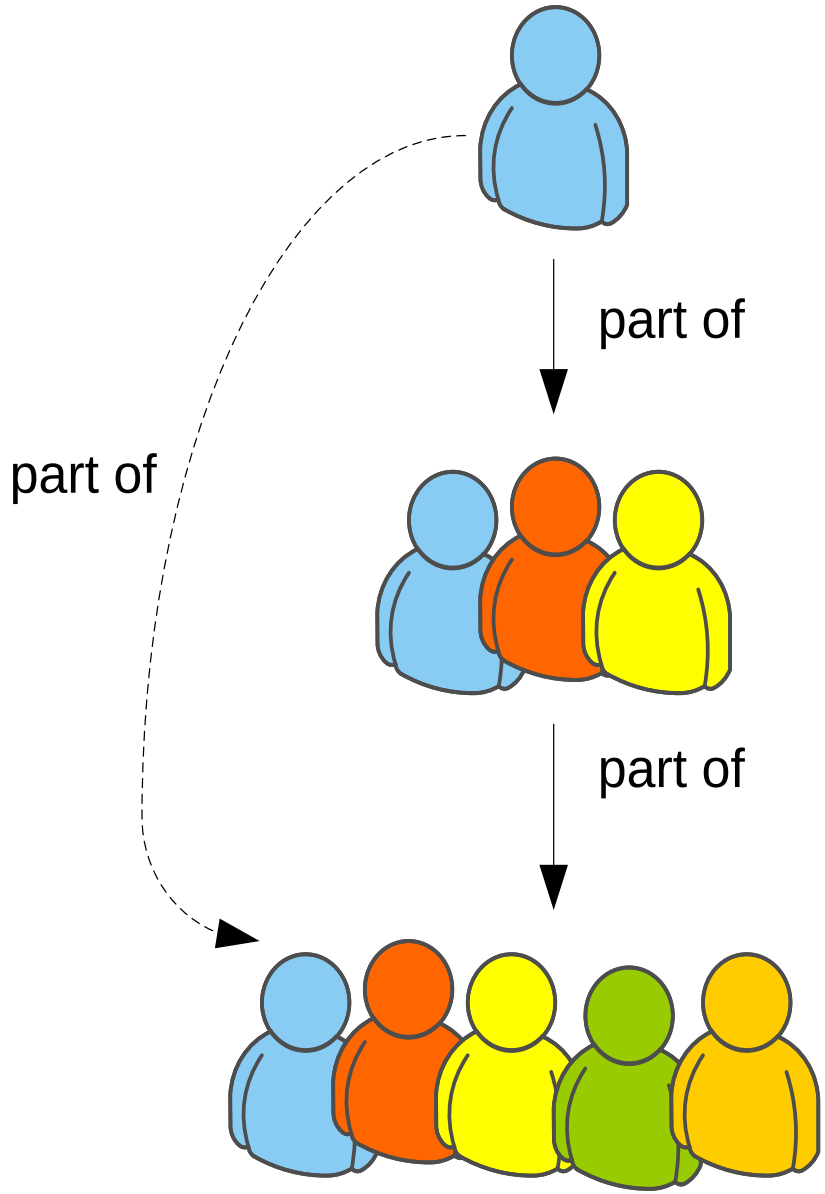
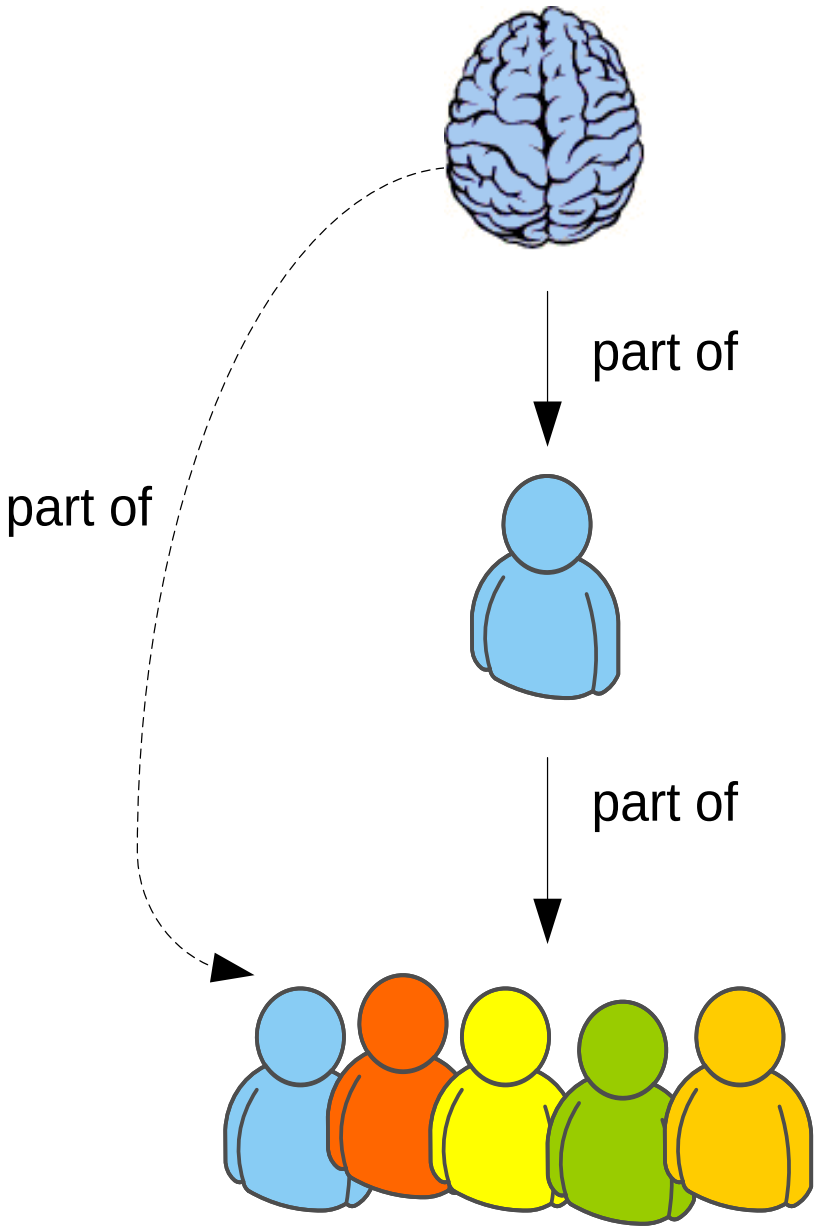
Ferrari Spyder



João

NEMO

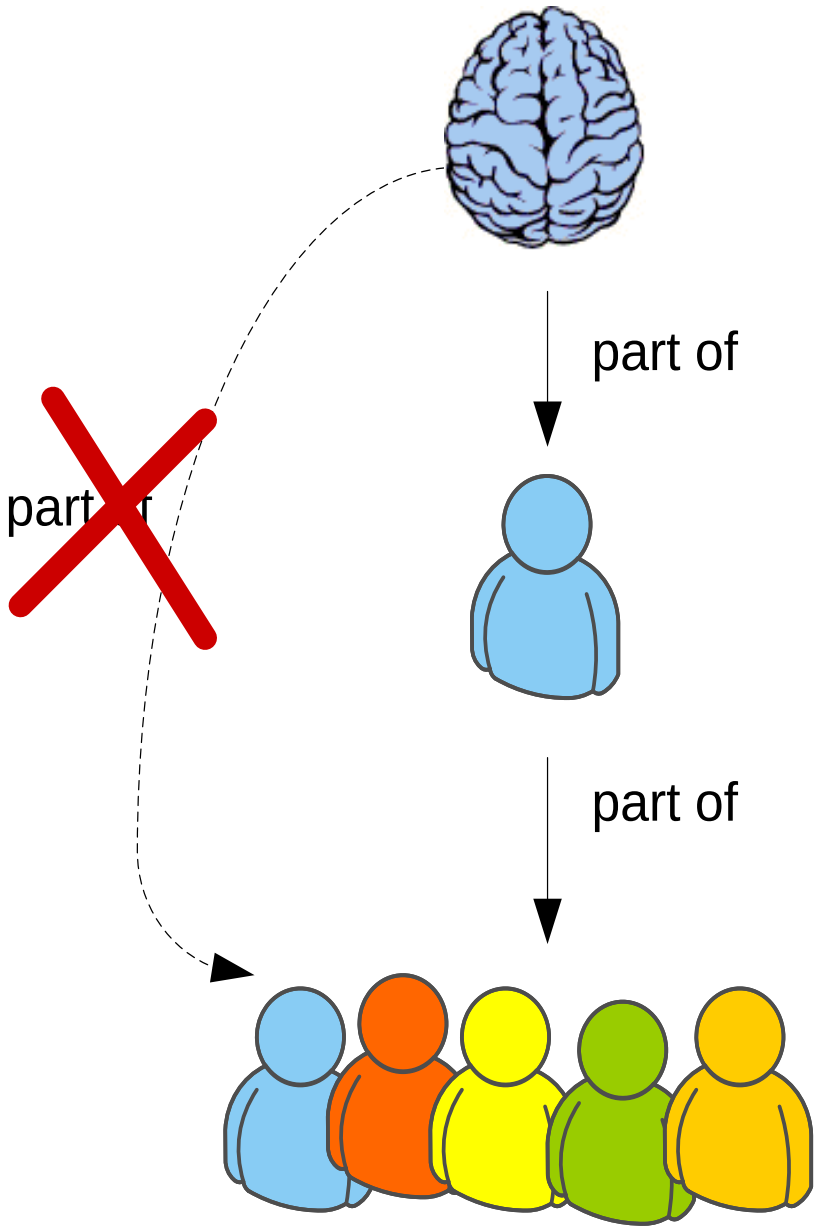
UFES



João´s Brain

João

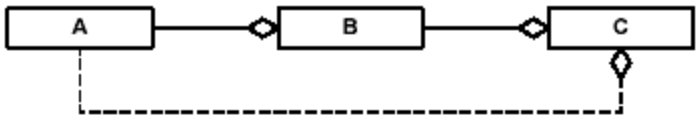
UFES



João´s Brain

João

UFES



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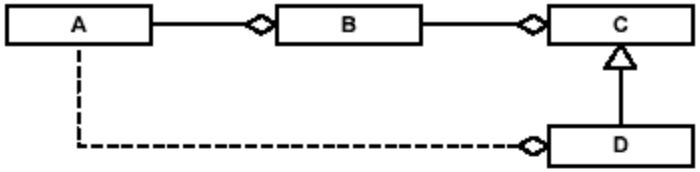

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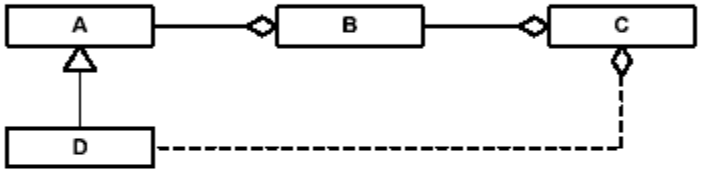

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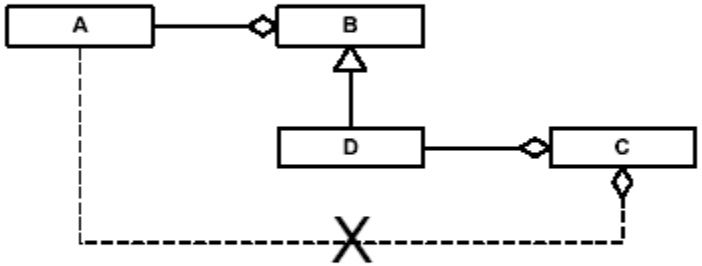

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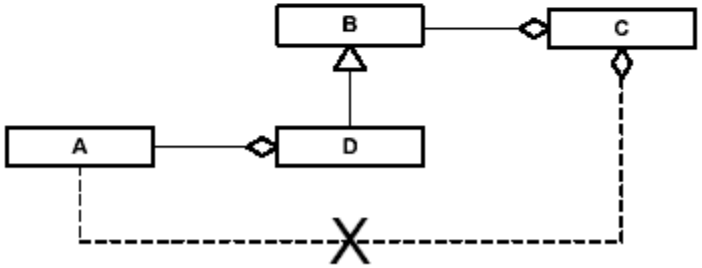

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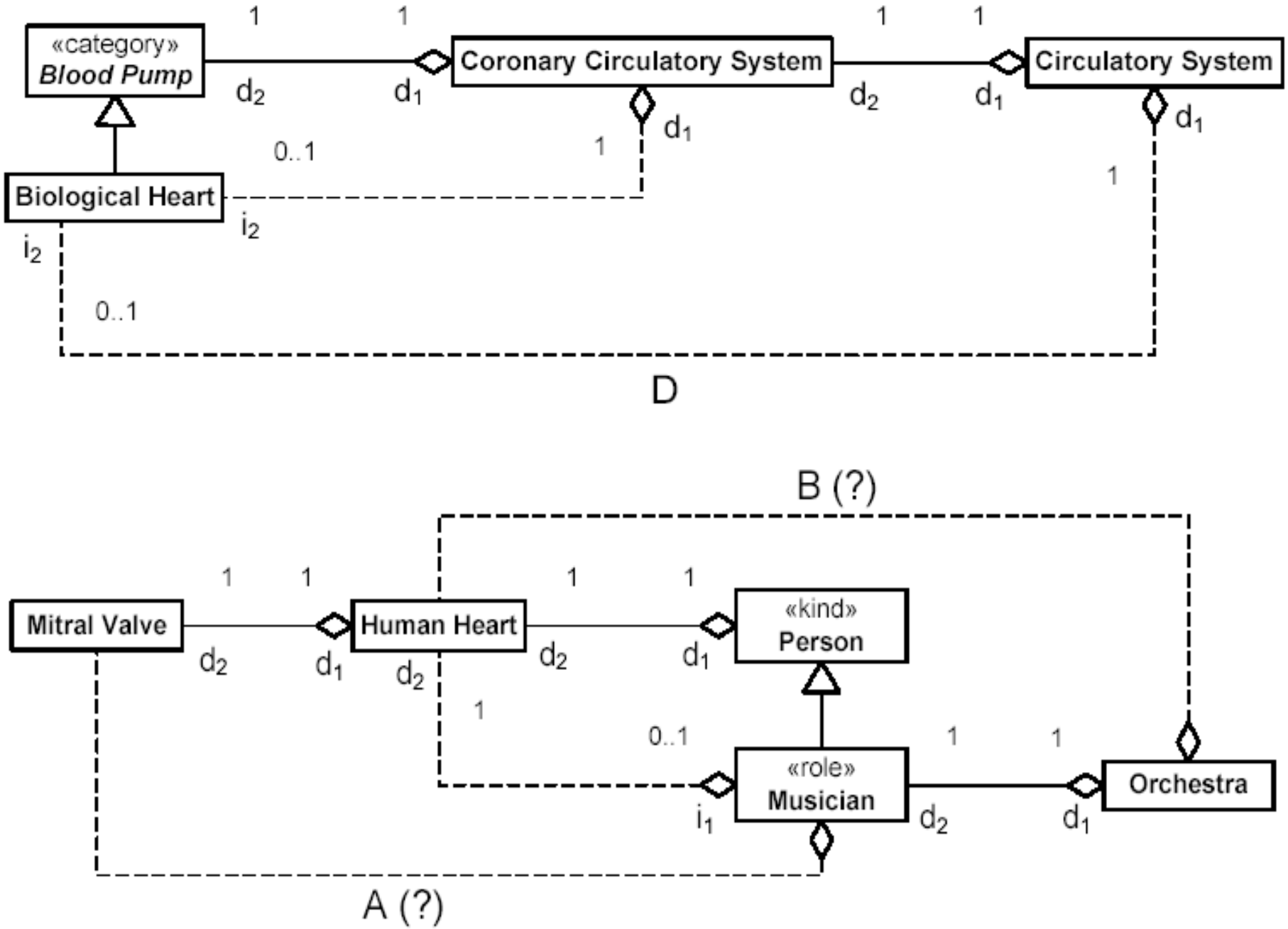
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Coronary Circulatory System
Circulatory System
Biological Heart
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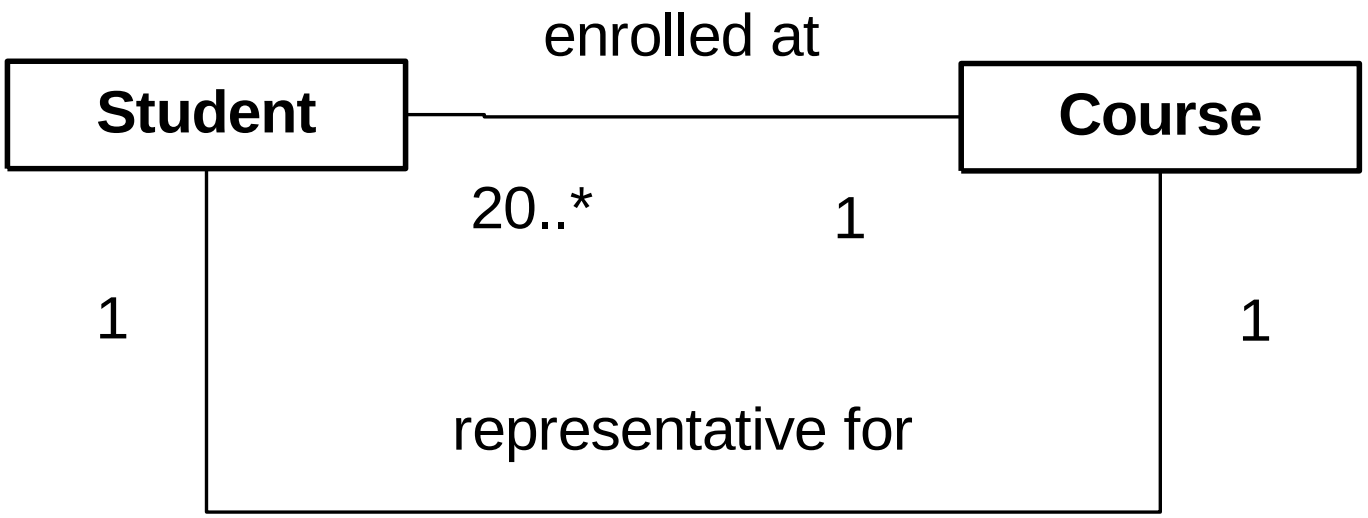
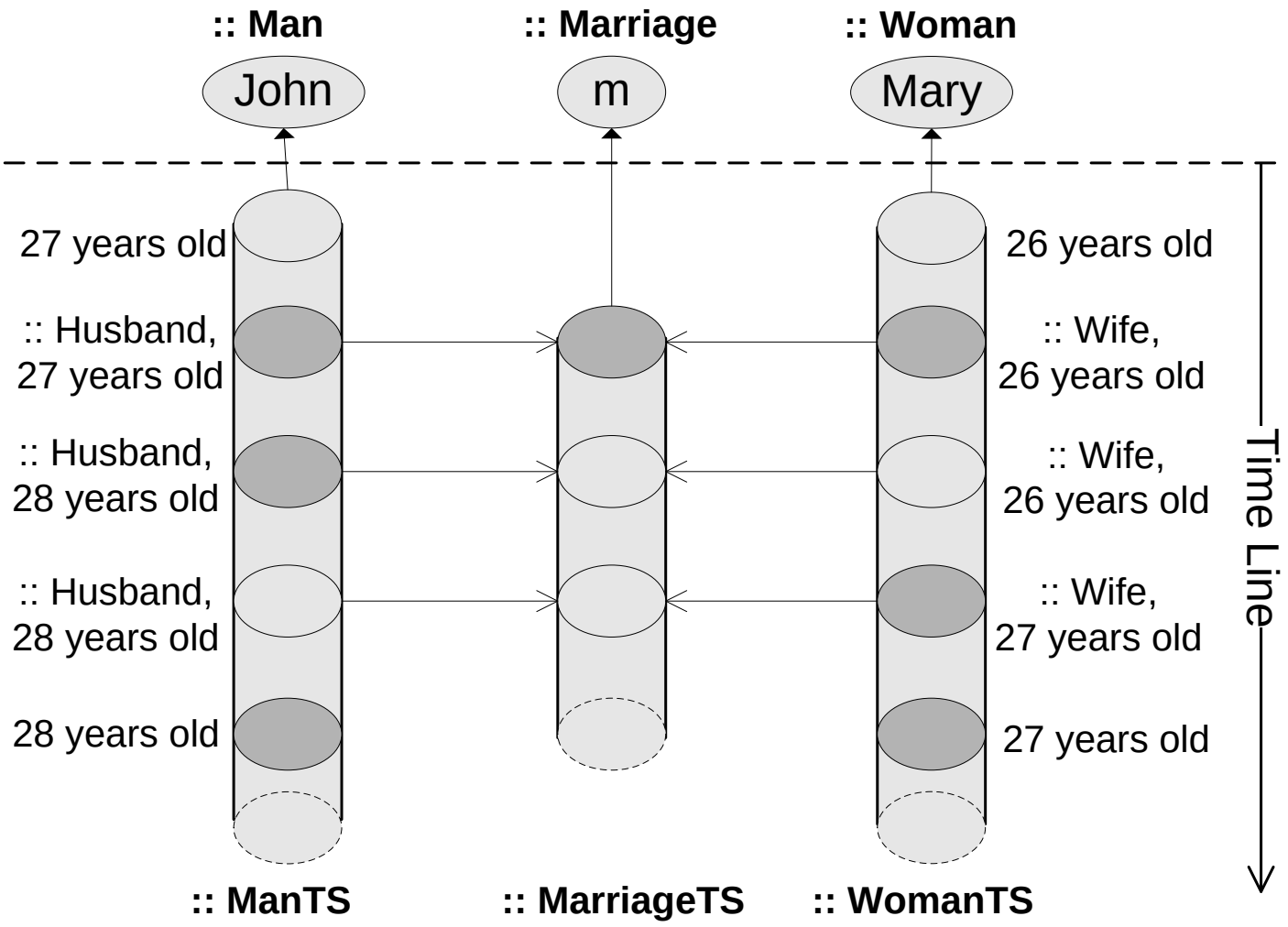
1
1
1
d2
d1
d2
d1
d1
d1
0..1
1
1
i2
i2
0..1
D
B (?)
Mitral Valve
Human Heart
«kind»
Person
«role»
Musician
Orchestra
1
1
1
1
1
1
0..1
1
1
d2
d1
d2
d2
d1
i1
d2
d1
A (?)


enrolled at
Student
Course
20..*
1
1
1
representative for


:: Man
:: Marriage
:: Woman
John
m
Mary
27 years old
:: Husband,
27 years old
:: Husband,
28 years old
:: Husband,
28 years old
28 years old
26 years old
:: Wife,
26 years old
:: Wife,
26 years old
:: Wife,
27 years old
27 years old
Time Line
:: ManTS
:: MarriageTS
:: WomanTS

Relevant Reference

Guizzardi, G.; Masolo, C.; Borgo, S. "In the Defense of a Trope-Based Ontology for Conceptual Modeling: An Example with the Foundations of Attributes, Weak Entities and Datatypes", 25th International Conference on Conceptual Modeling (ER'2006), Arizona, USA, 2006.

Guizzardi, G.; Wagner, G.; Guarino, N.; van Sinderen, M.

"An Ontologically Well-Founded Profile for UML Conceptual Models", (6th International Conference on Advances in Information Systems Engineering (CAiSE), Latvia, 2004.Springer-Verlag , Berlin, Lecture Notes in Computer Science 3084, ISBN 3-540-22151-4.

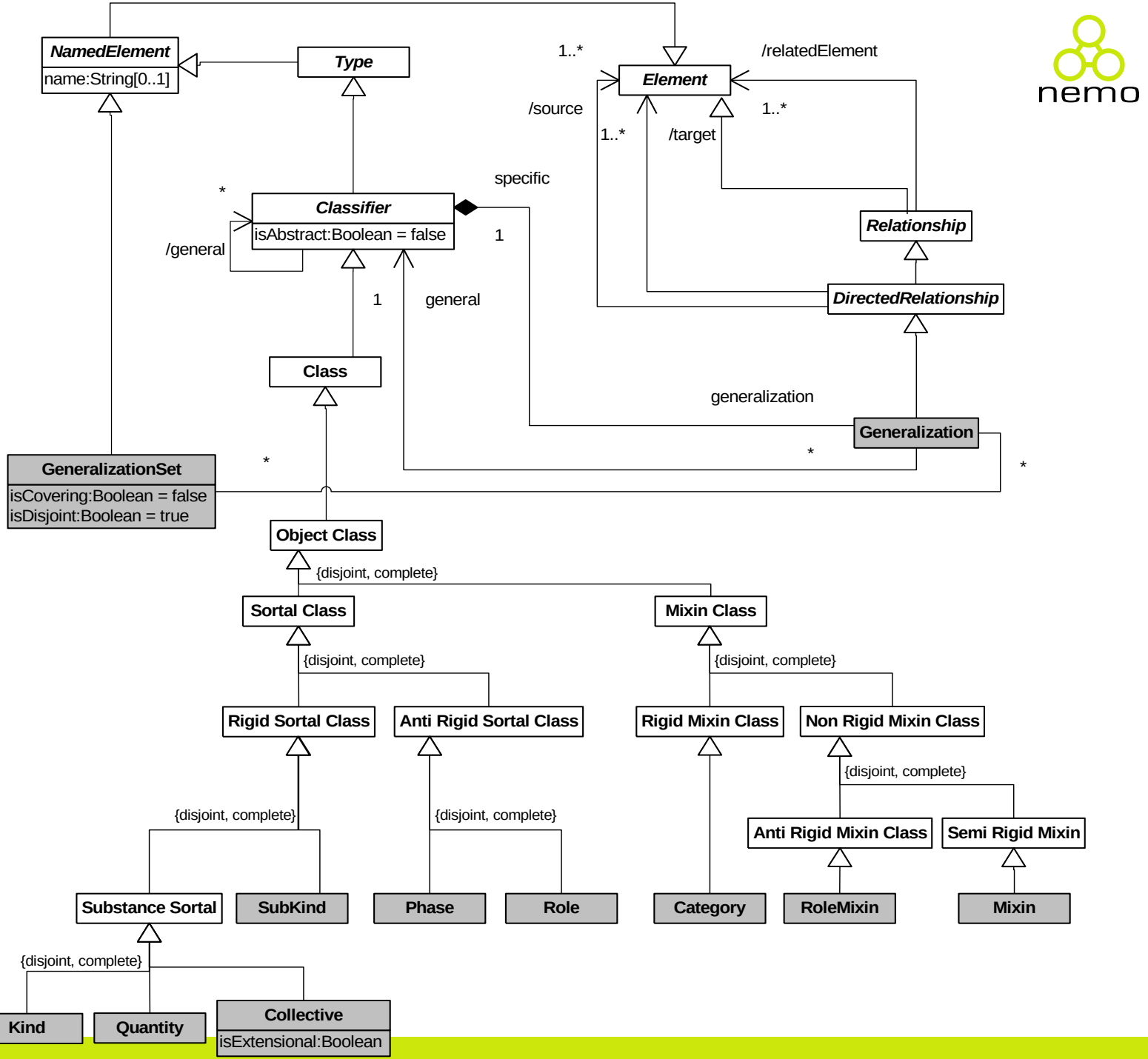
Relevant Reference

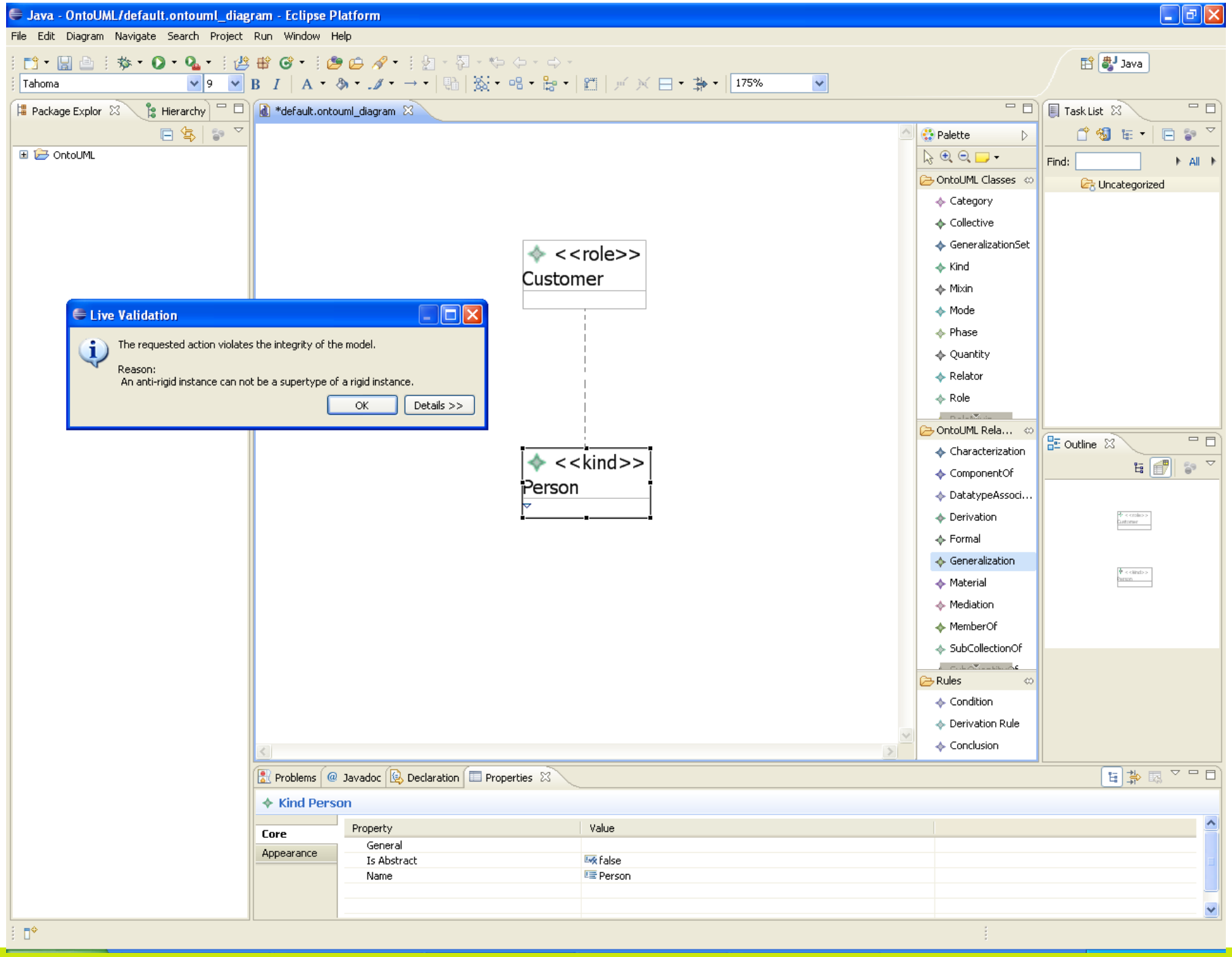
Guizzardi, G. “The Problem of Transitivity of Part-Whole Relations in Conceptual Modeling Revisited,” 21st International Conference on Advanced Information Systems Engineering (CAISE’09), Amsterdam, The Netherlands, 2009.

Zamborlini, V.; Guizzardi, G., “On the representation of temporally changing information in OWL,” IEEE 5th Joint International Workshop on Vocabularies, Ontologies and Rules for The Enterprise (VORTE) – Metamodels, Ontologies and Semantic Technologies (MOST), together with 15th International Enterprise Computing Conference (EDOC 2010), Vitória, Brazil, 2010.

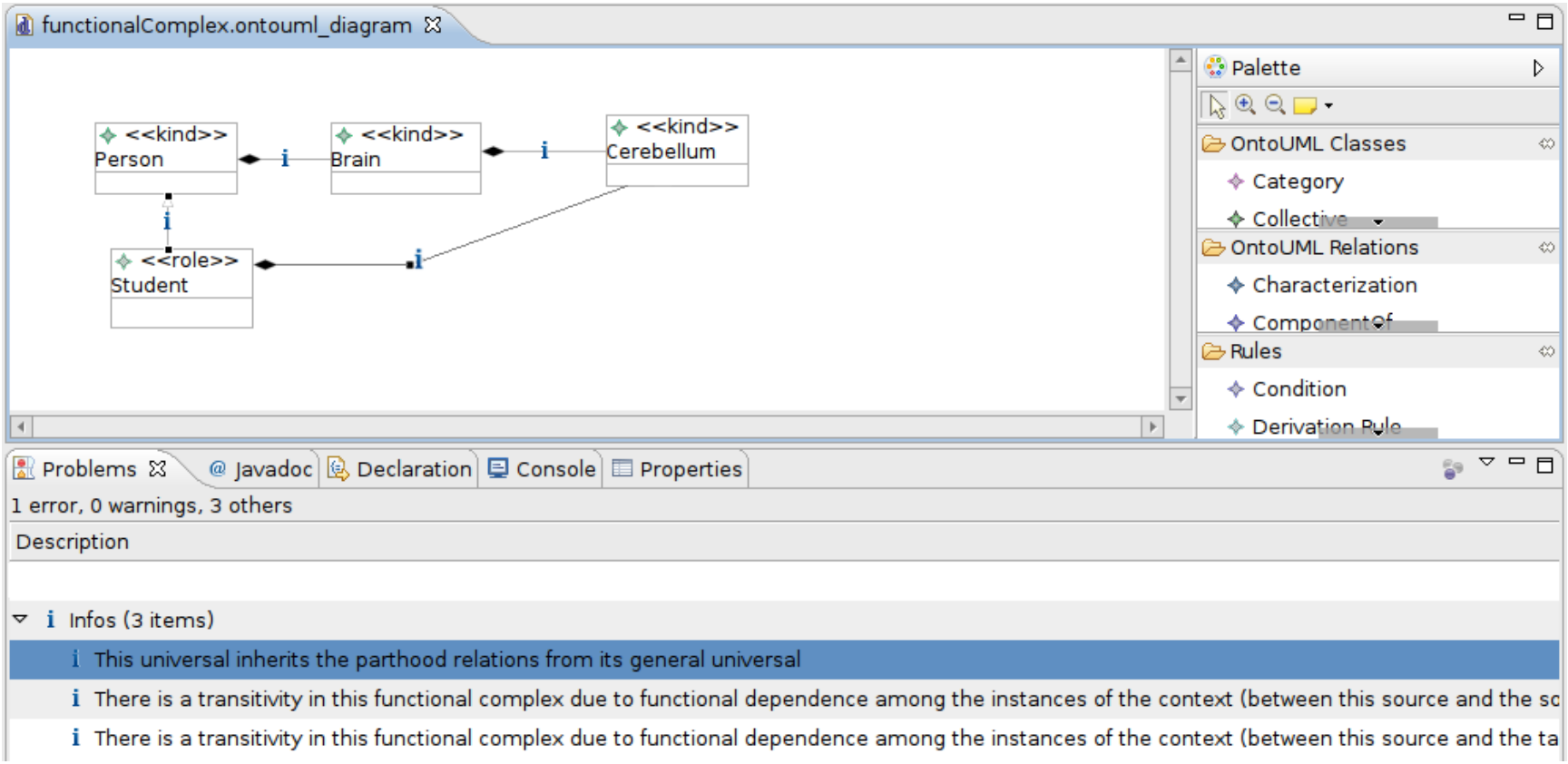
Guizzardi, G.; Wagner, G. “On A Unified Foundational Ontology and some Applications of it in Business Modeling”, Open INTEROP Workshop on Enterprise Modelling and Ontologies for Interoperability, 16th International Conference on Advances in Information Systems Engineering (CAiSE), Latvia, 2004.

4. We need tools to create, verify, validate and handle the complexity of the produced models

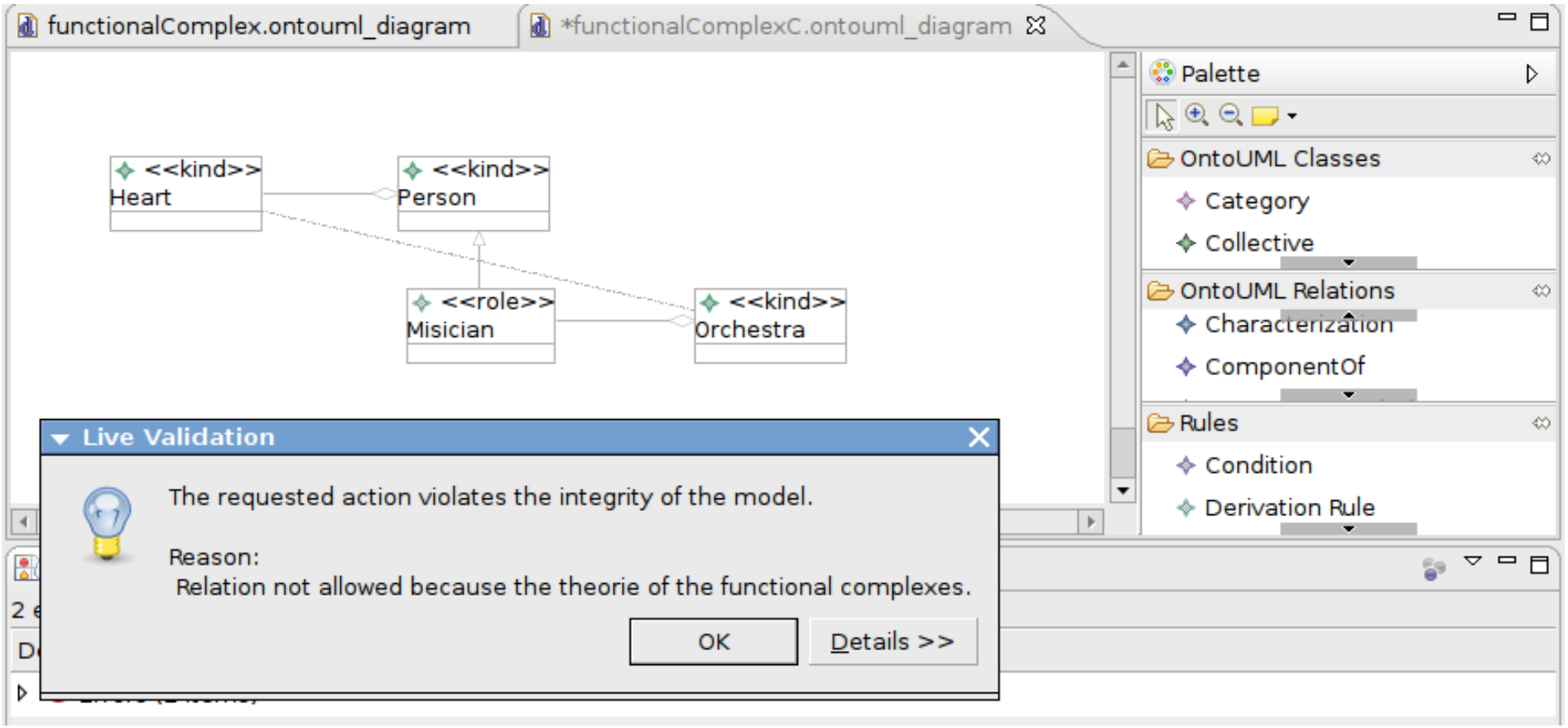

NamedElement
name:String[0..1]
Type
1..*
/relatedElement
Element
/source
1..*
1..*
/target
specific
*
Classifier
isAbstract:Boolean = false
1
/general
Relationship
DirectedRelationship
1
general
Class
generalization
Generalization
*
*
*
GeneralizationSet
isCovering:Boolean = false
isDisjoint:Boolean = true
Object Class
{disjoint, complete}
Sortal Class
Mixin Class
{disjoint, complete}
{disjoint, complete}
Rigid Sortal Class
Anti Rigid Sortal Class
Rigid Mixin Class
Non Rigid Mixin Class
{disjoint, complete}
{disjoint, complete}
{disjoint, complete}
Anti Rigid Mixin Class
Semi Rigid Mixin
Substance Sortal
SubKind
Phase
Role
Category
RoleMixin
Mixin
{disjoint, complete}
Kind
Quantity
Collective
isExtensional:Boolean

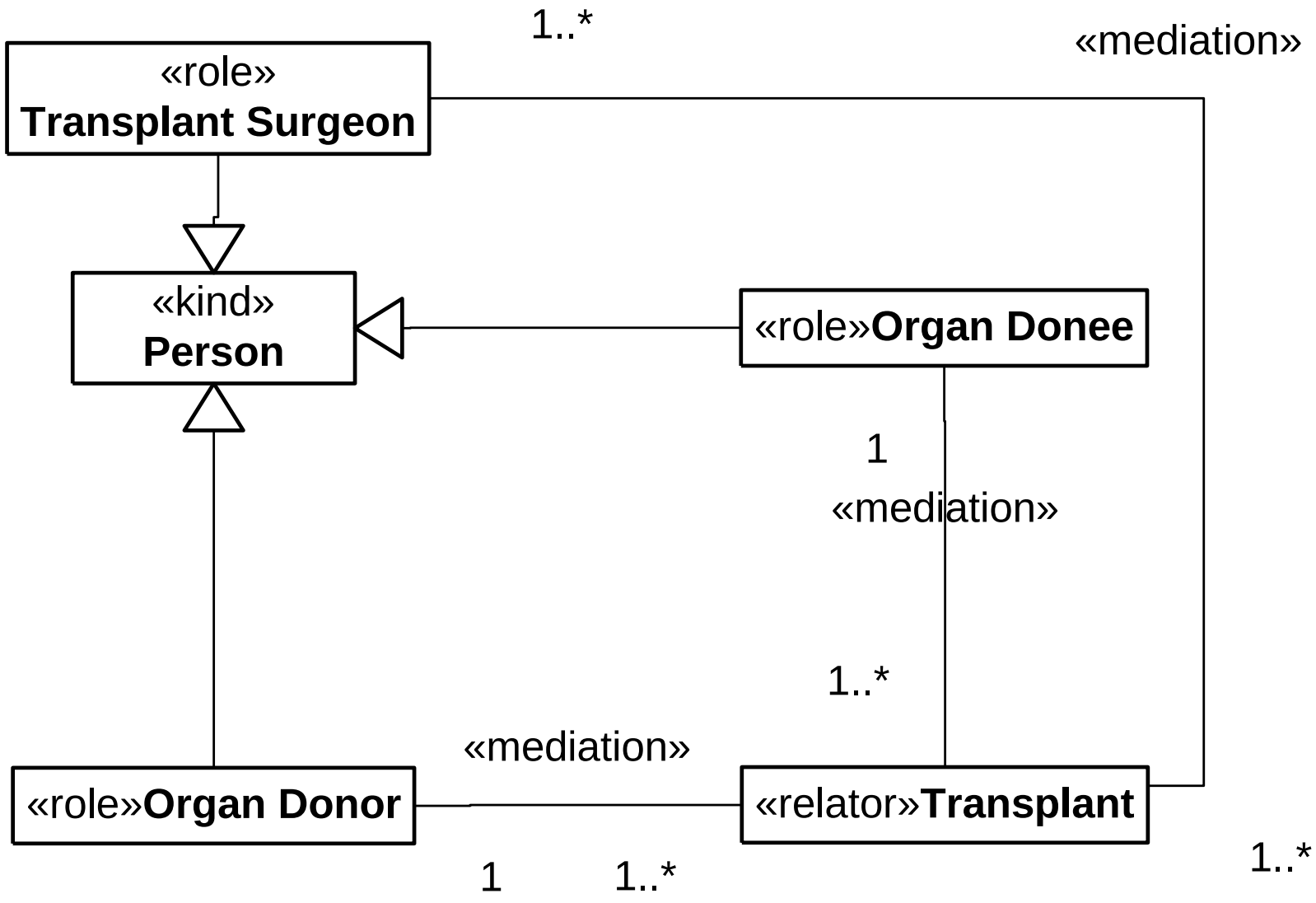

Java - OntoUML/default.ontouml_diagram - Eclipse Platform
File Edit Diagram Navigate Search Project Run Window Help
Java
Tahoma
9
175%
Package Explor
Hierarchy
OntoUML
*default.ontouml_diagram
<<role>>
Customer
<<kind>>
Person
Live Validation
The requested action violates the integrity of the model.
Reason:
An anti-rigid instance can not be a supertype of a rigid instance.
OK
Details >>
Palette
OntoUML Classes
Category
Collective
GeneralizationSet
Kind
Mixin
Mode
Phase
Quantity
Relator
Role
OntoUML Rela...
Characterization
ComponentOf
DatatypeAssoci...
Derivation
Formal
Generalization
Material
Mediation
MemberOf
SubCollectionOf
Rules
Condition
Derivation Rule
Conclusion
Task List
Find:
All
Uncategorized
Outline
Problems
Javadoc
Declaration
Properties
Kind Person
Core
Appearance
Property
Value
General
Is Abstract
false
Name
Person

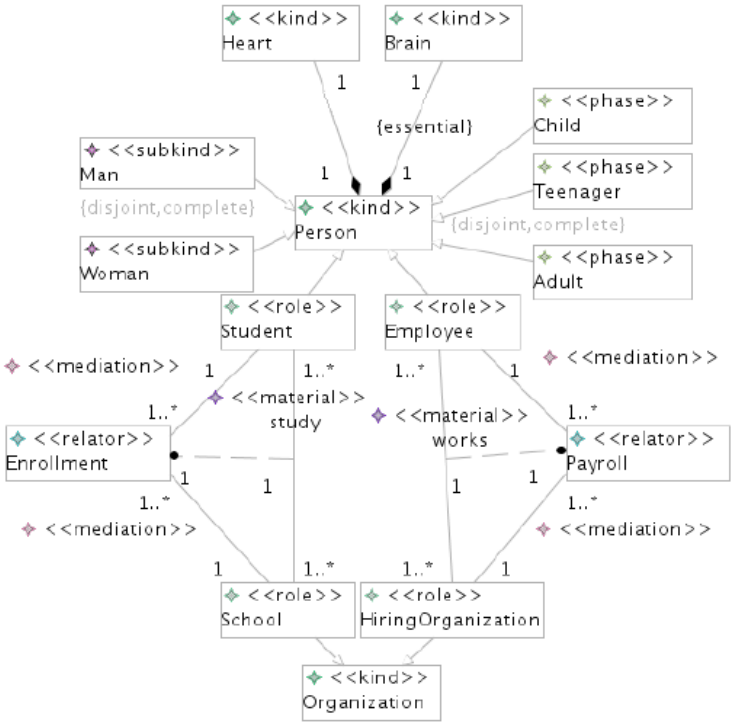
Tool Support



The underlying algorithm merely has to check structural properties of the diagram and not the content of involved nodes


functionalComplex.ontouml_diagram
*functionalComplexC.ontouml_diagram
<<kind>>
Heart
<<kind>>
Person
<<role>>
Misician
<<kind>>
Orchestra
Palette
OntoUML Classes
Category
Collective
OntoUML Relations
Characterization
ComponentOf
Rules
Condition
Derivation Rule
Live Validation
The requested action violates the integrity of the model.
Reason:
Relation not allowed because the theorie of the functional complexes.
OK
Details >>


1..*
«mediation»
«role»
Transplant Surgeon
«kind»
Person
«role»Organ Donee
1
«mediation»
1..*
«mediation»
«role»Organ Donor
«relator»Transplant
1
1..*
1..*

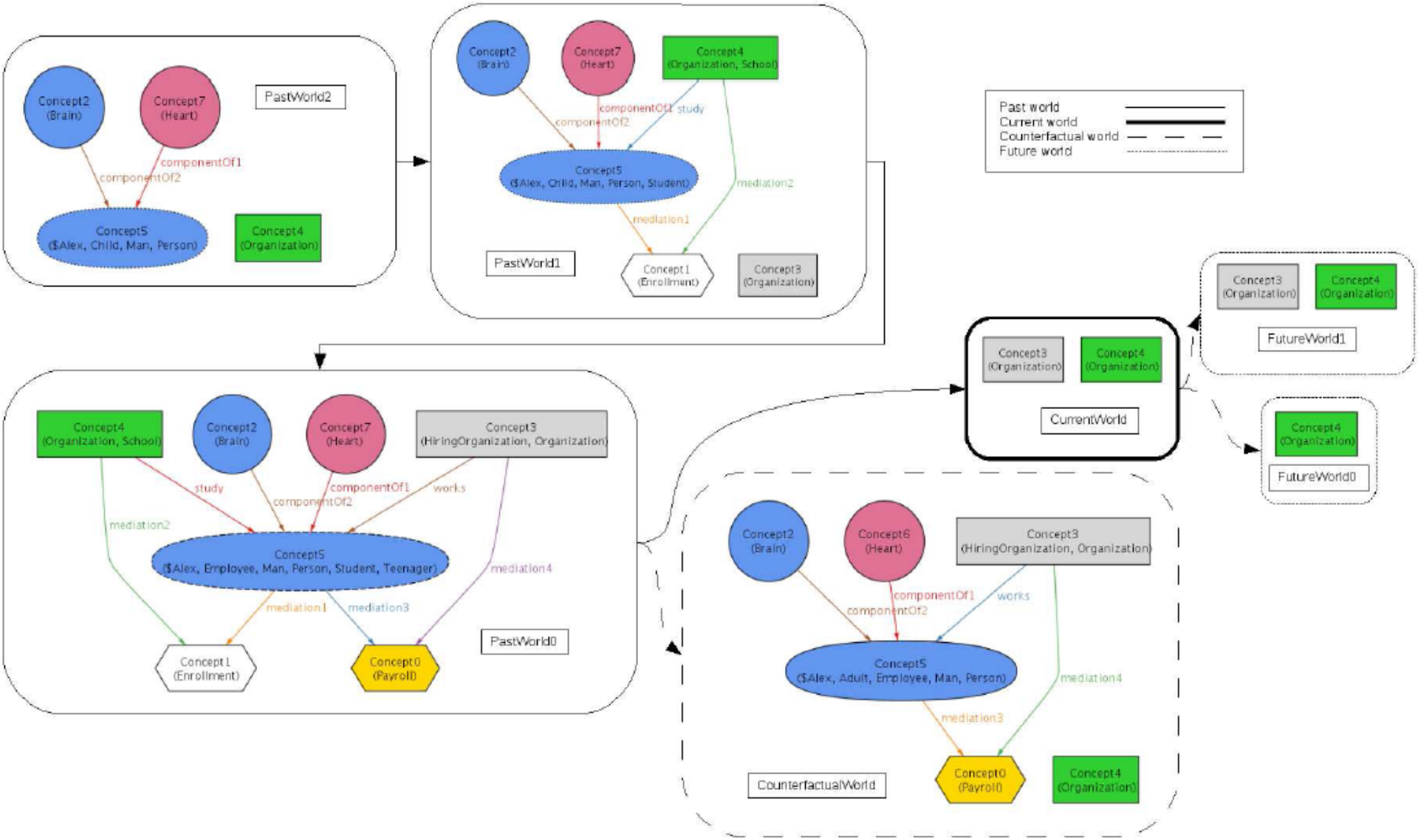


ATL Transformation

```
1 sig Person_Set in Concept { Person: some World }
2 {
3   Person in existsIn
4   all w1: World | w1 in Person => (all w2:
        w1.access | (w2 in existsIn) => (w2 in
        Person)) -- Rigidity
5   some w: World | w in this.Child -- Phase
6   some w: World | w in this.Teenager -- Phase
7   some w: World | w in this.Adult -- Phase
    :
8
9 }
```

Simulation and Visualization

Alloy Analyzer + OntoUML visual Plugin


Concept2
(Brain)
Concept7
(Heart)
componentOf1
componentOf2
Concept5
($Alex, Child, Man, Person)
Concept4
(Organization)
PastWorld2
Concept2
(Brain)
Concept7
(Heart)
Concept4
(Organization, School)
componentOf1
componentOf2
study
Concept5
($Alex, Child, Man, Person, Student)
mediation2
mediation1
PastWorld1
Concept1
(Enrollment)
Concept3
(Organization)
Past world
Current world
Counterfactual world
Future world
Concept3
(Organization)
Concept4
(Organization)
FutureWorld1
Concept3
(Organization)
Concept4
(Organization)
CurrentWorld
Concept4
(Organization)
FutureWorld0
Concept4
(Organization, School)
Concept2
(Brain)
Concept7
(Heart)
Concept3
(HiringOrganization, Organization)
study
componentOf2
componentOf1
works
mediation2
Concept5
($Alex, Employee, Man, Person, Student, Teenager)
mediation4
mediation1
mediation3
PastWorld0
Concept1
(Enrollment)
Concept0
(Payroll)
Concept2
(Brain)
Concept6
(Heart)
Concept3
(HiringOrganization, Organization)
componentOf1
componentOf2
works
Concept5
($Alex, Adult, Employee, Man, Person)
mediation4
mediation3
CounterfactualWorld
Concept0
(Payroll)
Concept4
(Organization)

Relevant Reference

Benevides, A.B.; Guizzardi, G. “A Model-Based Tool for Conceptual Modeling and Domain Ontology Engineering in OntoUML,” 11th International Conference on Enterprise Information Systems (ICEIS), Milan, 2009. Lecture Notes in Business Information Processing, Springer-Verlag.

Guizzardi, G.; Graças, A.P., Guizzardi, R.S.S., “Design Patterns and Inductive Modeling Rules to Support the Construction of Ontologically Well-Founded Conceptual Models in OntoUML”,3rd International Workshop on Ontology-Driven Information Systems (ODISE 2011), together with the 23rd International Conference on Advanced Information System Engineering (CAiSE'11), London, UK.

Relevant Reference

Benevides, A.B.; Guizzardi, G.; Braga, B.F.B.; Almeida, J.P.A., "Validating modal aspects of OntoUML conceptual models using automatically generated visual world structures", Journal of Universal Computer Science, Special Issue on Evolving Theories of Conceptual Modeling, Editors: Klaus-Dieter Schewe and Markus Kirchberg, 2010.

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