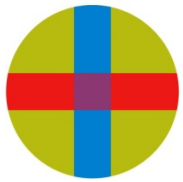


CEU
Universidad
San Pablo

GENERAL ONTOLOGIES

Course in Ontologies and the Semantic Web in the Master in Artificial Intelligence at UPM

Invited teacher: Mariano Fernández López

Presentation based on Mariano Fernández-López, Asunción Gómez-Pérez & Mari Carmen Suárez-Figueroa's work

OUTLINE

1. Presentation of general ontologies
2. The work to be done by the student

PRESENTATION OF GENERAL ONTOLOGIES

1. Presentation of general ontologies
2. The work to be done by the student

PRESENTATION OF GENERAL ONTOLOGIES. OUTLINE

1. Bibliography
2. The notion of general ontology
3. Some important types of general ontologies
4. The reuse of general ontologies

BIBLIOGRAPHY (I)

1. Bibliography
2. The notion of general ontology
3. Some important types of general ontologies
4. The reuse of general ontologies

BIBLIOGRAPHY (II)

OVERVIEW ON GENERAL ONTOLOGIES

Gómez-Pérez A, Fernández-López M, Corcho O (2003) *Ontological Engineering*. Springer Verlag, London (section 2.2)

TIME ONTOLOGIES

Hayes PJ (1995) *A Catalog of Temporal Theories*. Technical Report UIUC-BI-AI-96-01 at the Beckman Institute and Departments of Philosophy and Computer Science University of Illinois. *http://www.ihmc.us/users/phayes/docs/timeCatalog.pdf*

Hobbs JR, Feng P (eds) (2006) *Time Ontologies in OWL*. W3C Working Draft 2. *http://www.w3.org/TR/owl-time/*

MEREOLOGY AND TOPOLOGY

Varzi A (2007) *Spatial Reasoning and Ontology: Parts, Wholes, and Locations*. In Aiello M, Pratt-Hartmann I, van Benthem J (eds) Springer-Verlag, pp 945-1038 (It also includes space modeling)

Varzi A (2003) *Mereology*. In Zalta EN, Nodelman U, Allen C (eds) Stanford Encyclopedia of Philosophy, Stanford: CSLI (on line publication) (*http://plato.stanford.edu/entries/mereology/*) (last access: 19th January 2010)

Rector A, Welty C (eds), Noy N, Wallace E (contributors) (2005) *Simple part-whole relations in OWL Ontologies* . W3C Editors Draft (http://www.w3.org/2001/sw/BestPractices/OEP/SimplePartWhole/)

BIBLIOGRAPHY (III)

HOW TO REUSE GENERAL ONTOLOGIES

Fernández-López M, Gómez-Pérez A (2004) *Searching for a Time Ontology for Semantic Web Applications*. In: Varzi A, Vieu L (eds) 3rd International Conference on Formal Ontologies and Information Systems. Torino, Italy, pp 331-341 (It also includes a compilation of time features).

Fernández-López M, Gómez-Pérez A, Suárez-Figueroa MC (2008) *Selecting and Customizing a Mereology Ontology for its Reuse in a Pharmaceutical Product Ontology*. In: Eschenbach C, Grüninger M (eds) 5th International Conference on Formal Ontologies and Information Systems. Saarbrücken, Germany, pp 181-194 (It also includes a compilation of mereology features)

Suárez-Figueroa MC (coord) (2008) *D5.4.1. NeOn Methodology for Building Contextualized Ontology Networks*. NeOn Project IST-2005-027595 (It also includes a compilation of mereology features)

Suárez-Figueroa MC (2010) *NeOn Methodology for Building Ontology Networks: Specification, Scheduling and Reuse*. PhD Thesis, Facultad de Informática, Universidad Politécnica de Madrid, Spain (section 10.3)

THE NOTION OF GENERAL ONTOLOGY

1. Bibliography
2. The notion of general ontology
3. Some important types of general ontologies
4. The reuse of general ontologies

WHAT IS A GENERAL ONTOLOGY?

A common or general ontology specifies the conceptualization of a generic topic such as time, space, and mereology, and represents knowledge reusable in different domains.

Mizoguchi R, Vanwelkenhuysen J, Ikeda M (1995) *Task Ontology for reuse of problem solving knowledge*. In: Mars N (ed) Towards Very Large Knowledge Bases: Knowledge Building and Knowledge Sharing (KBKS'95). University of Twente, Enschede, The Netherlands. IOS Press, Amsterdam, The Netherlands, pp 46–57

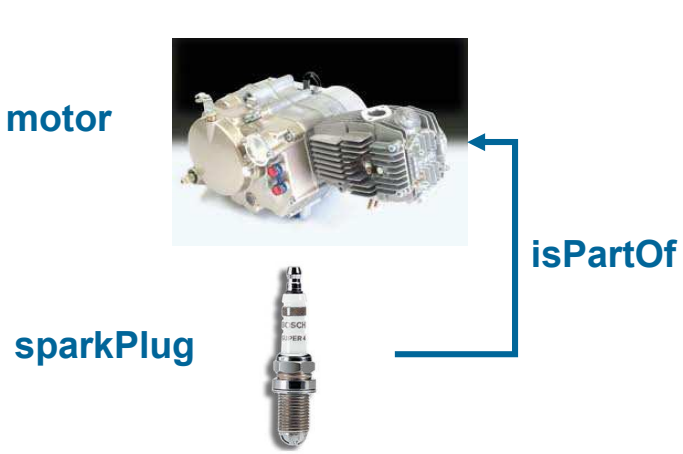
van Heijst G, Schreiber ATh, Wielinga BJ (1997) *Using explicit ontologies in KBS development*. International Journal of Human-Computer Studies 45:183–292

A CASE OF GENERAL ONTOLOGIES: MEREOLOGIES

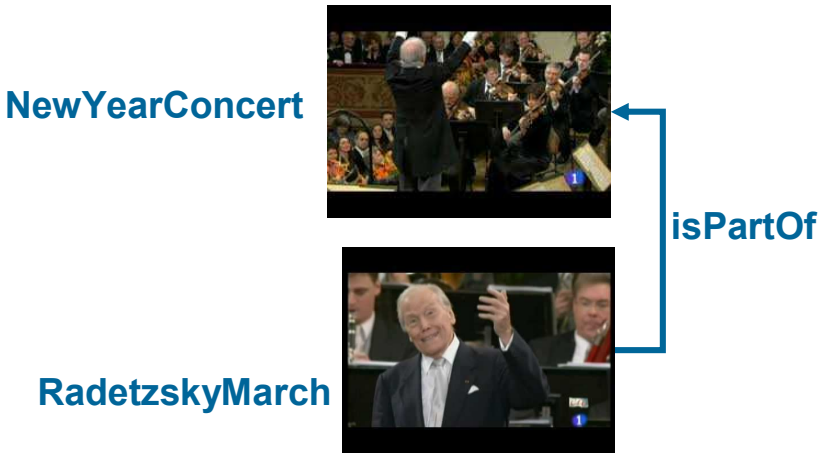
A mereology is a formal theory that axiomatizes the relation *isPartOf*.

Borst WN (1997) *Construction of Engineering Ontologies*. Centre for Telematica and Information Technology, University of Tweenty. Enschede, The Netherlands

Varzi A (2003) *Mereology*. In Zalta EN, Schneider L (2004) *How to Build a Foundational Ontology. The Object-Centered High-level Reference Ontology OCHRE*. Saarland University forthcoming publication. (*http://www.ifomis.unisaarland.de/Research/Publications/forthcoming/ki2003epaper.pdf*)



http://t3.gstatic.com/images?q=tbn:ANd9GcSlInRjO37O6BWuoNVc-
http://www.bosch.com.mx/content/language2/img_productworlds/bujia_super4.jpg



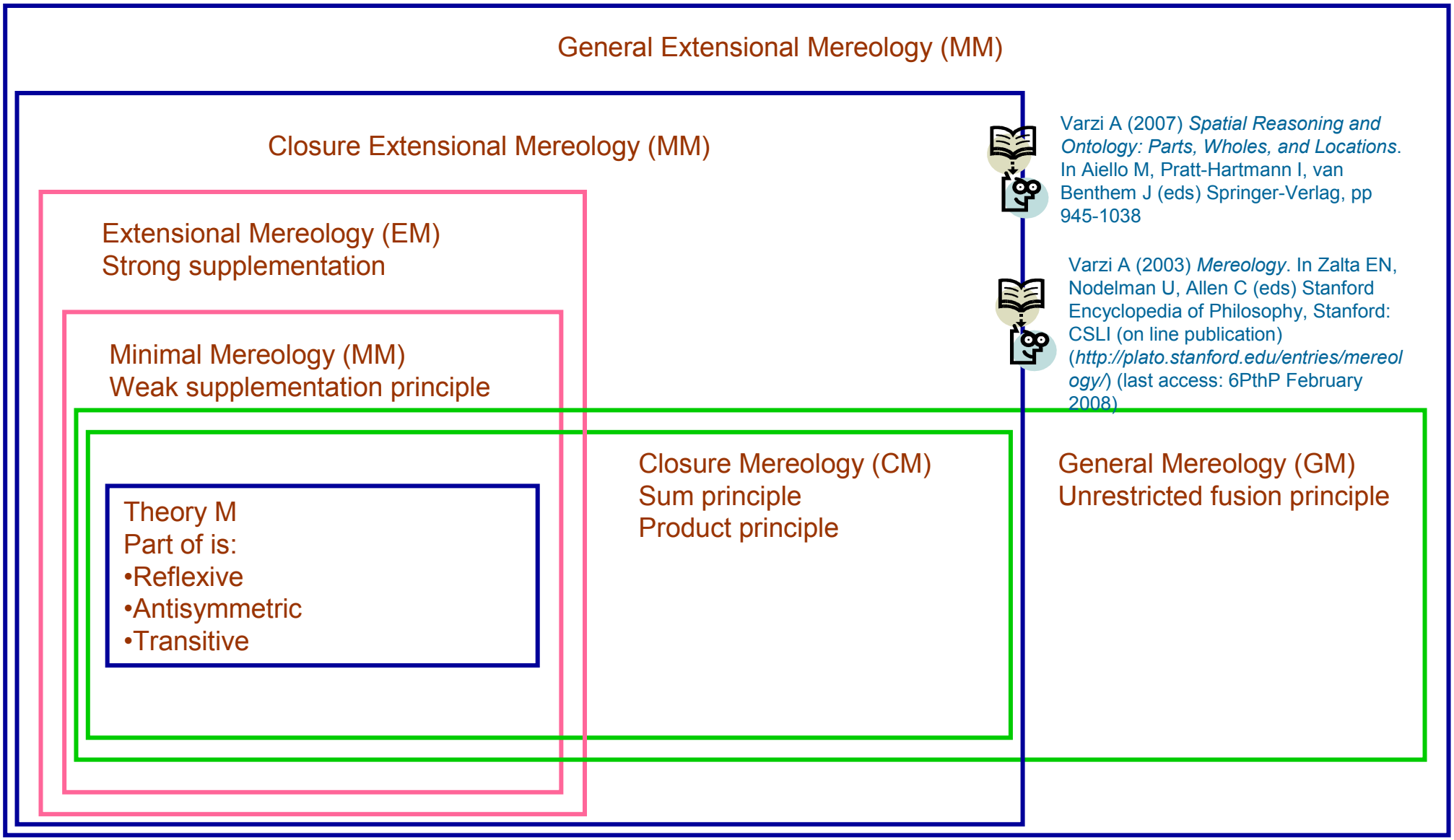
http://i.ytimg.com/vi/u6cbhlto9sA/hqdefault.jpg
http://i.ytimg.com/vi/6o7dmM3YNN8/hqdefault.jpg

Lets note that the part of relation links objects in the mechanical domain (the spark plug is part of the motor), and also in the domain of cultural activities (the interpretation of Radetzsky March is part of the New Year Concert).

SOME IMPORTANT TYPES OF GENERAL ONTOLOGIES

1. Bibliography
2. The notion of general ontology
3. Some important types of general ontologies
   a. Mereologies
   b. Time ontologies
4. The reuse of general ontologies

MEREOLOGIES



Varzi A (2007) *Spatial Reasoning and Ontology: Parts, Wholes, and Locations*. In Aiello M, Pratt-Hartmann I, van Benthem J (eds) Springer-Verlag, pp 945-1038

Varzi A (2003) *Mereology*. In Zalta EN, Nodelman U, Allen C (eds) Stanford Encyclopedia of Philosophy, Stanford: CSLI (on line publication) (*http://plato.stanford.edu/entries/mereology/*) (last access: 6PthP February 2008)

MINIMAL MEREOLOGY

EXAMPLE

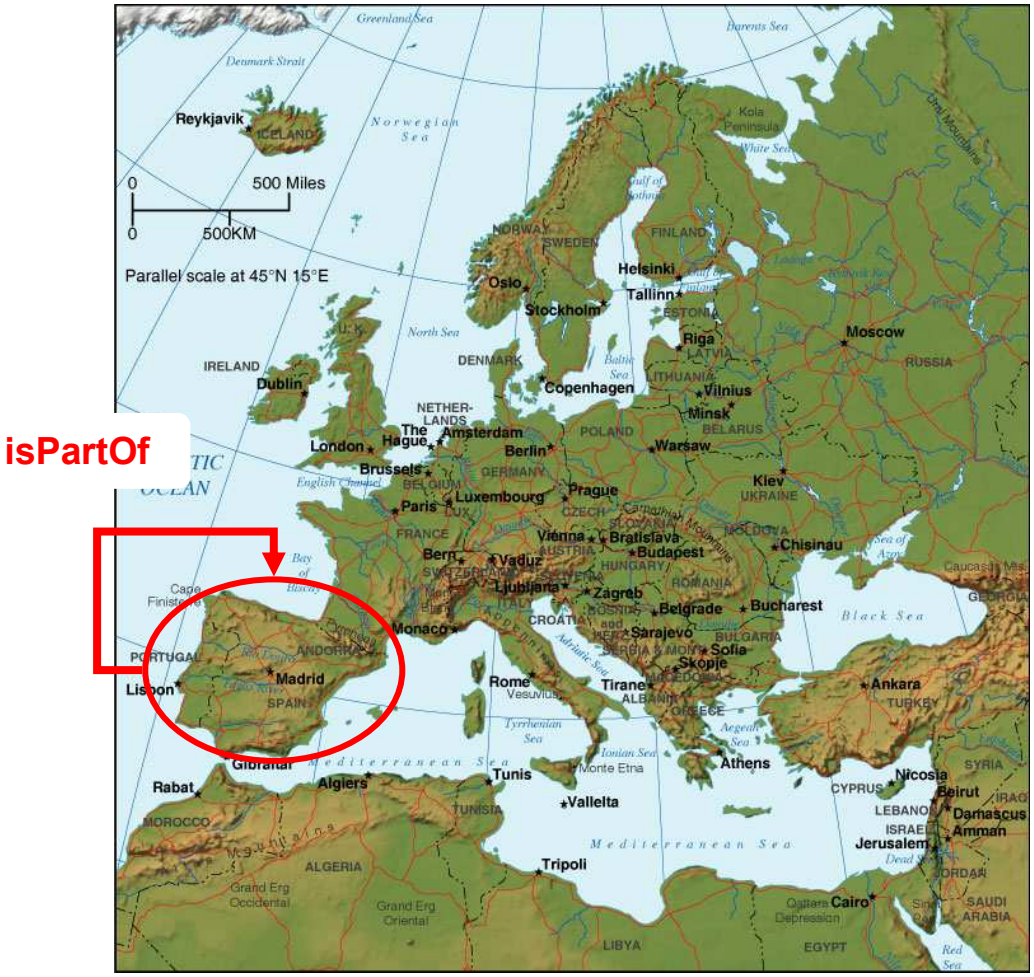
Minimal Mereology (MM)
Weak supplementation principle

Theory M
Part of is:
•Reflexive
•Antisymmetric
•Transitive

http://europa.eu/abc/maps/images/europe.gif

MINIMAL MEREOLOGY. REFLEXIVITY

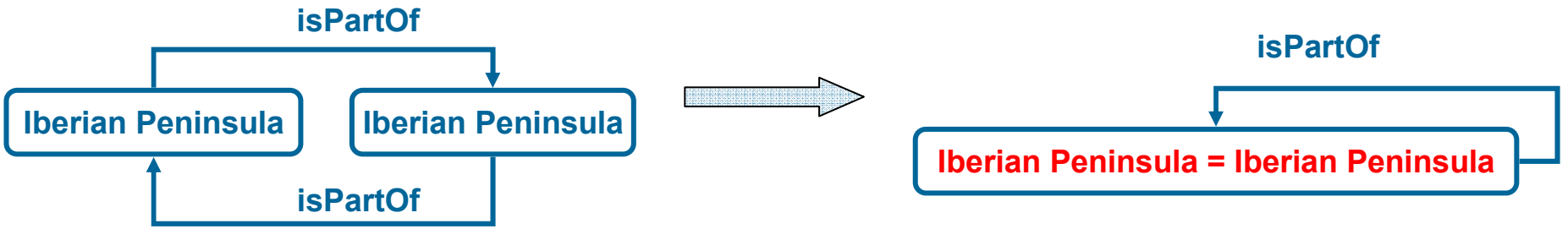
Reflexivity. Every object of the universe of discourse is a part of itself.



http://www.map-of-europe.us/europe-relief-map.jpg

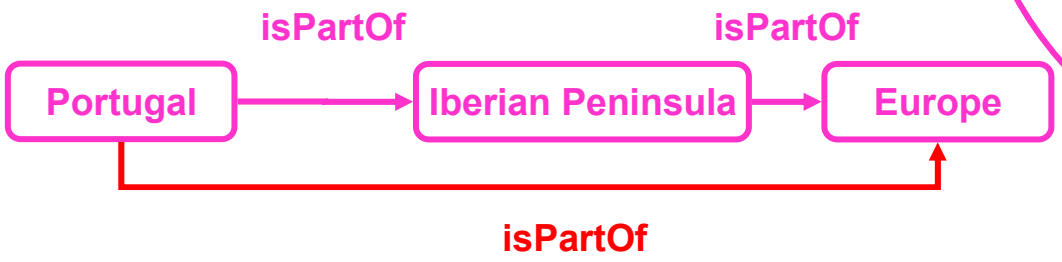
MINIMAL MEREOLOGY. ANTISYMMETRY

Antisymmetry. If an object *x* is a part of *y*, and *y* is a part of *x*, then *x* and *y* are the same object.



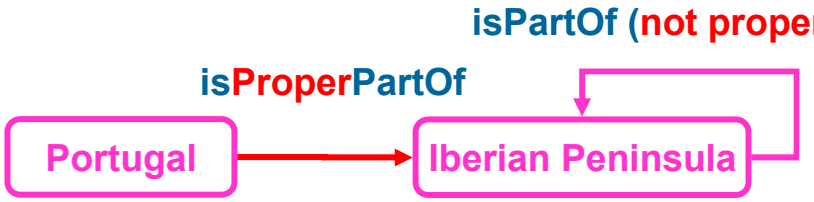
MINIMAL MEREOLOGY. TRANSITIVITY

Transitivity. If *x* is a part of *y*, and *y* is a part of *z*, then *x* is a part of *z*.



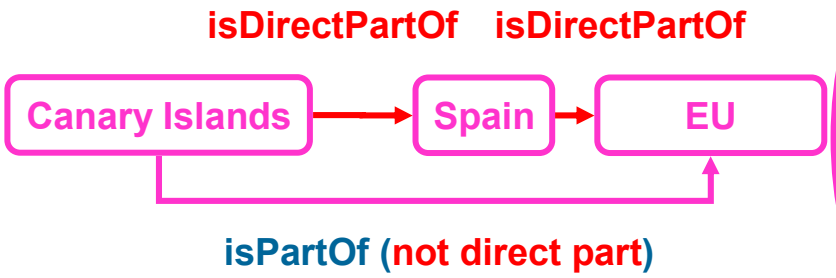
MINIMAL MEREOLOGY. PROPER PART

A **proper part** is a part that is other than the individual itself.



MINIMAL MEREOLOGY. DIRECT PART

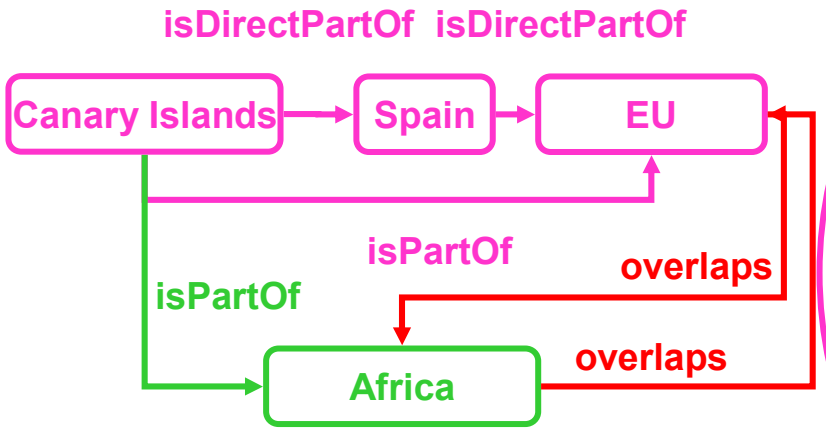
X is **direct part** of *y* if and only if *x* is proper part of *y* and there is no part between *x* and *y*.



http://europa.eu/abc/maps/images/europe.gif

MINIMAL MEREOLOGY. OVERLAPS

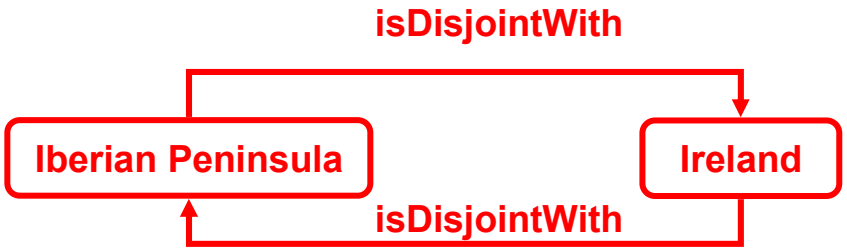
The relation **overlaps** is defined as a sharing part. That is, *x* and y overlap if and only if there is a *z* such us *z* is part of *x* and part of *y*.



http://europa.eu/abc/maps/images/europe.gif

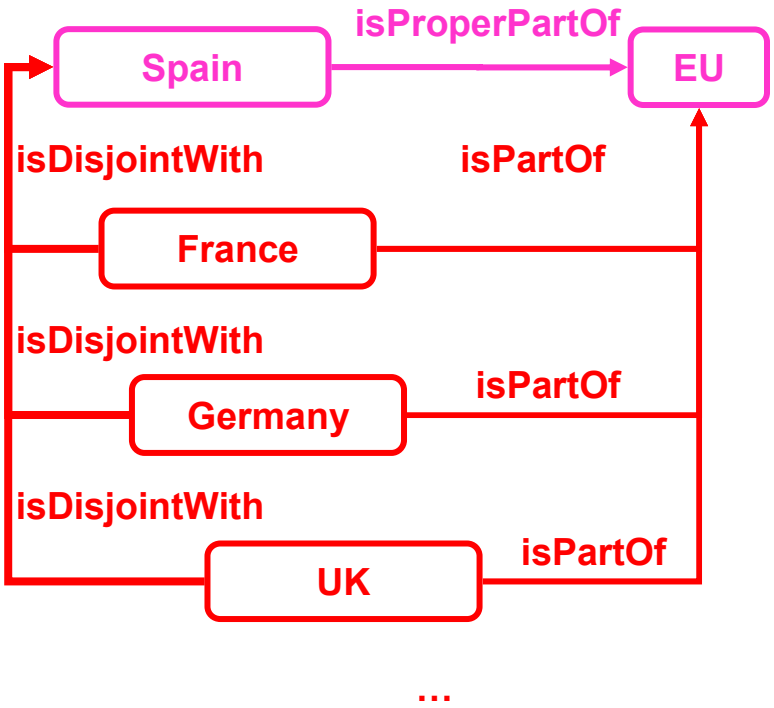
MINIMAL MEREOLOGY. IS DISJOINT WITH

The **disjoint** relation is the logical negation of overlaps.

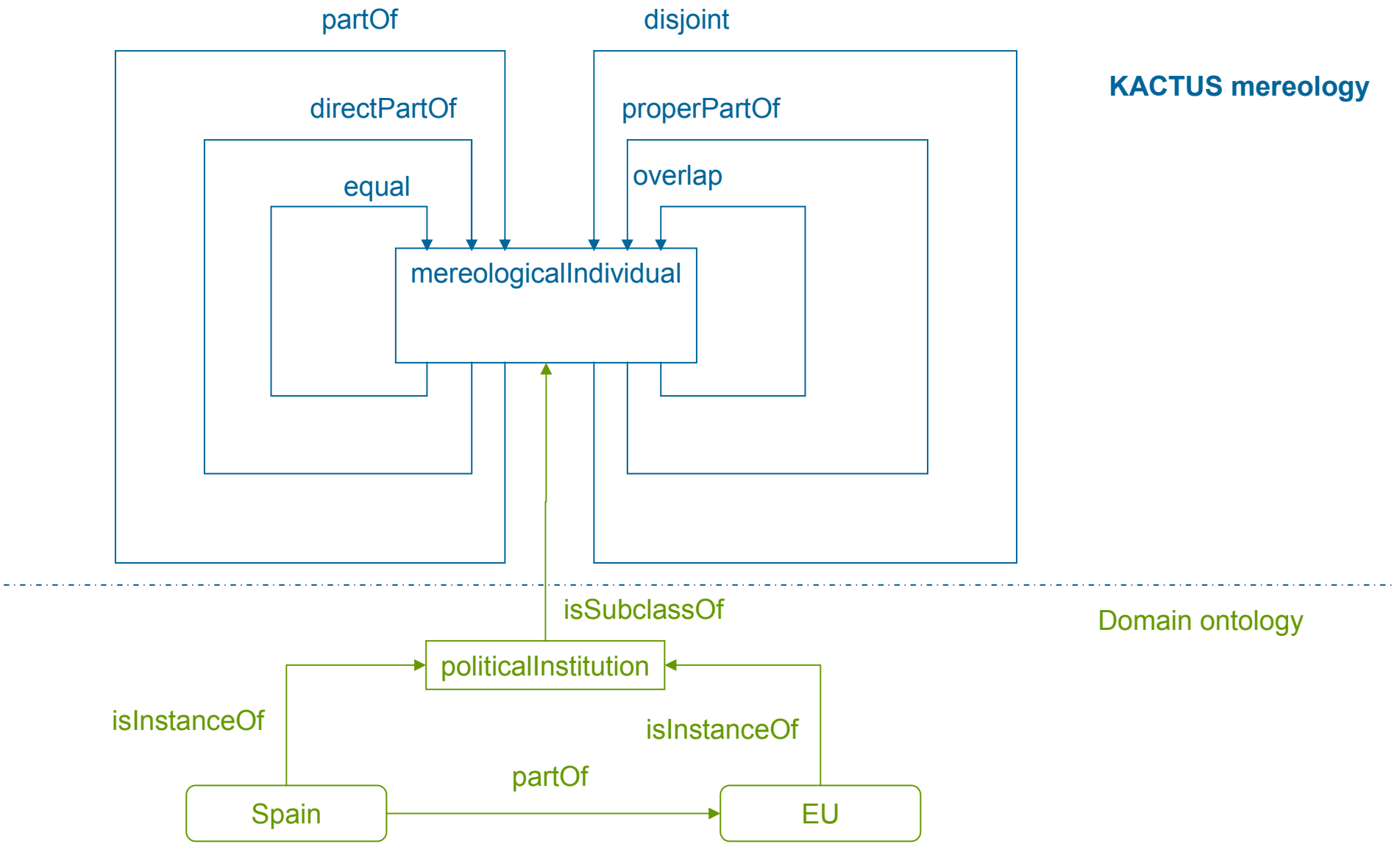


MINIMAL MEREOLOGY (VII)

Weak supplementation principle. Every object *x* with a proper part *y* has another part *z* that is disjoint from *y*.



KACTUS MEREOLOGY



TIME ONTOLOGIES

1. Bibliography
2. The notion of general ontology
3. Some important types of general ontologies
   a. Mereologies
   b. Time ontologies
4. The reuse of general ontologies

COMMON NOTIONS: TIME POINTS AND TIME INTERVALS

Time point. As a first intuitive approximation, we can see time points as points in the line time.

Example of representations of time points

http://carlokapuscinski.files.wordpress.com/2009/11/lina450.jpg

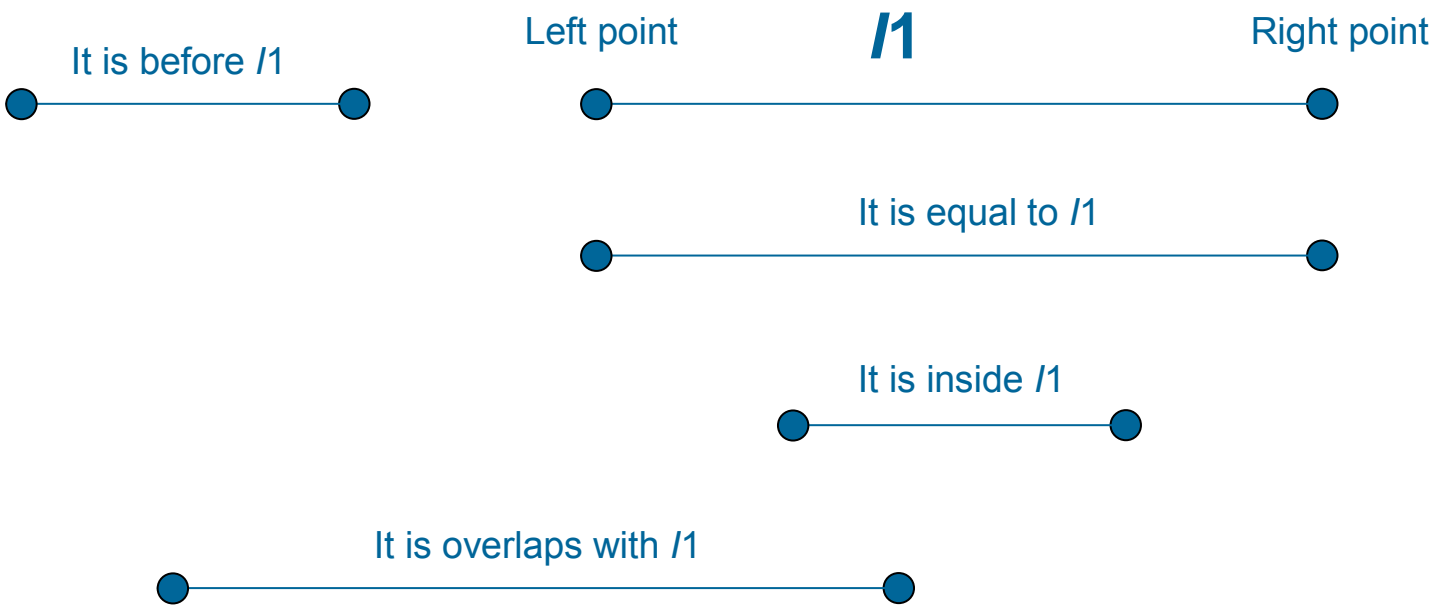
Granularity of days: Avelina Vidal's concert is celebrated the 8th of May of 2010

Granularity of minutes: Avelina Vidal's concert is celebrated the 8th of May of 2010 at 19:30

Time interval. Also as a first intuitive approximation, we can see a time interval as the time between two time points.

Left point — Right point

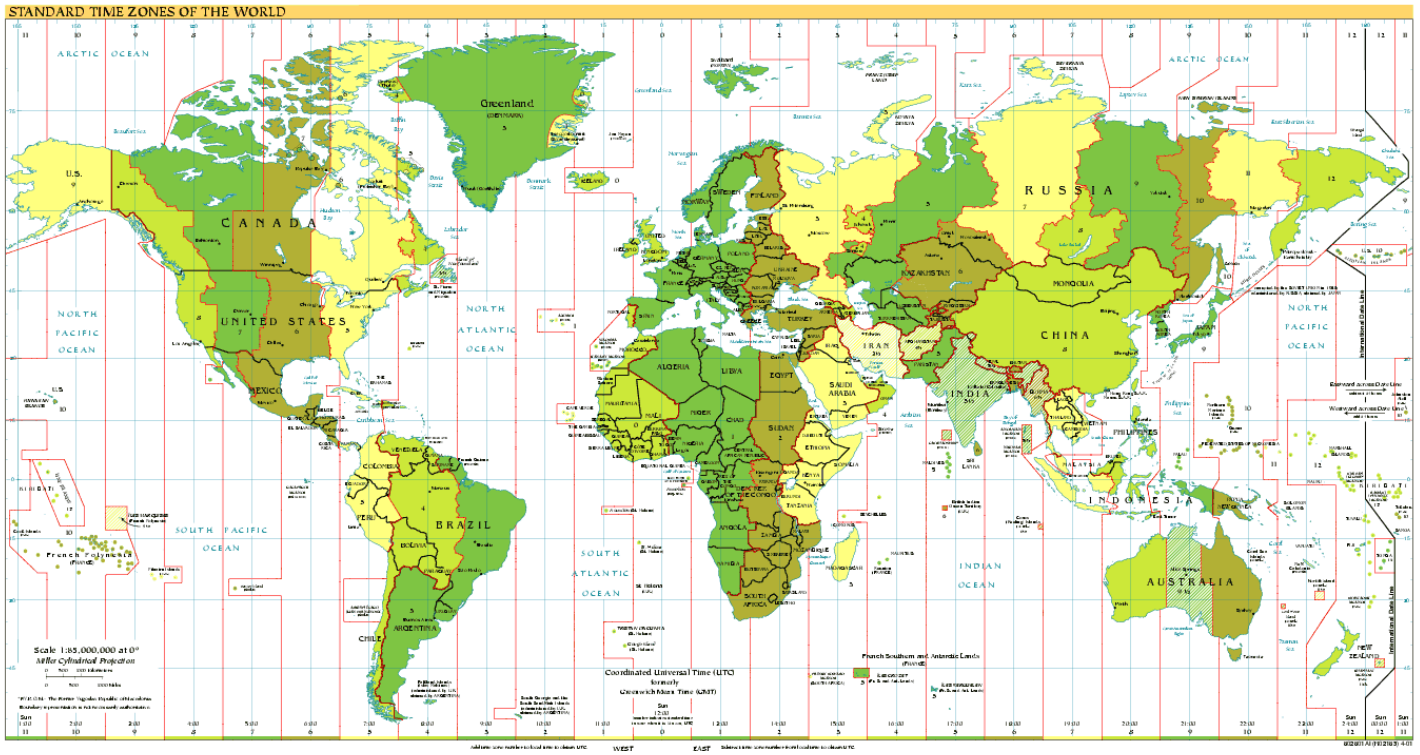
TIME INTERVAL ALGEBRA



COMMON NOTIONS: TIME ZONES

Time zones. The time in different places of the world.

http://www.tagoror.com/enciclopedia/es/media/4/4b/timezones.png

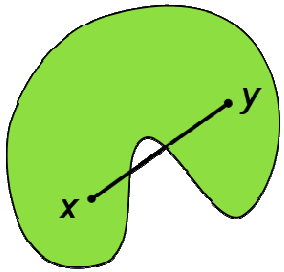


The axiomatization of time zones is complex. Thus, for example, the Northern and Southern hemispheres perform Daylight/Summer Time adjustments during opposing times during the year (corresponding to seasonal differences in the two hemispheres)

Phillips A, Sasaki F, Davis M, Dürst M (2005) *Working with Time Zones*. W3C Working Group Note (http://www.w3.org/TR/2005/NOTE-timezone-20051013/)

TIME MODELING. OPTIONAL EXTENSIONS (I)

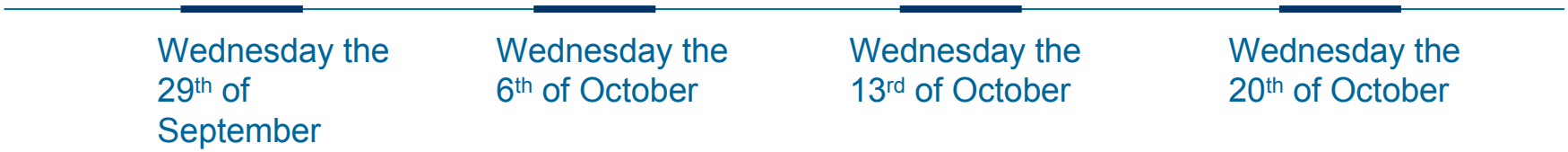
Non convex intervals. This notion is borrowed from geometry:



http://upload.wikimedia.org/wikipedia/commons/thumb/1/1f/Non_Convex_set.svg/329px-Non_Convex_set.svg.png

Non convex intervals. There are points between the left and the right points that do not belong to the interval:

Non convex intervals allow representing periodic intervals with gaps between them (e.g. “every Wednesday”).

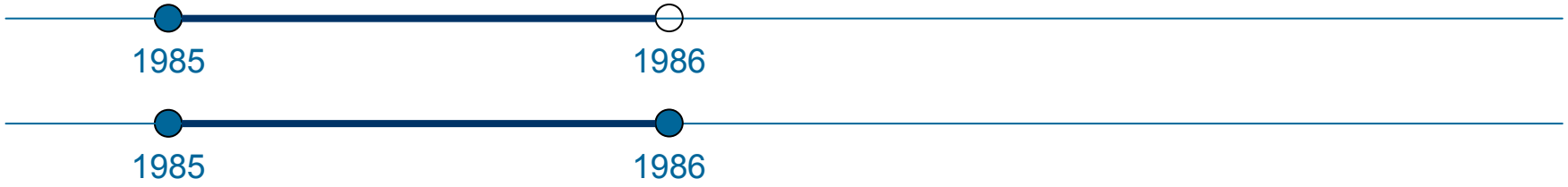


TIME MODELING. OPTIONAL EXTENSIONS (II)

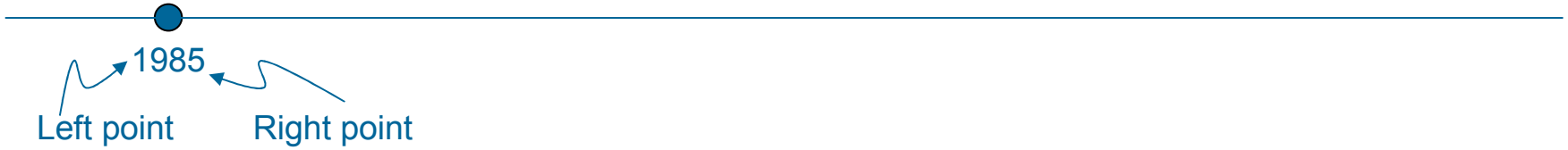
Open intervals. Sometimes, the interval end points might be or not included in the interval. For example, [1985, 1986) is an interval left closed and right open.

Distinction of proper intervals. A proper interval is that whose extremes are different is called proper. Thus, for example, [1985, 1986] is a proper interval, however, [1985, 1985] is not. Sometimes, the interval end points might be or not included in the interval. For example, [1985, 1986) is an interval left closed and right open.

Examples of proper intervals



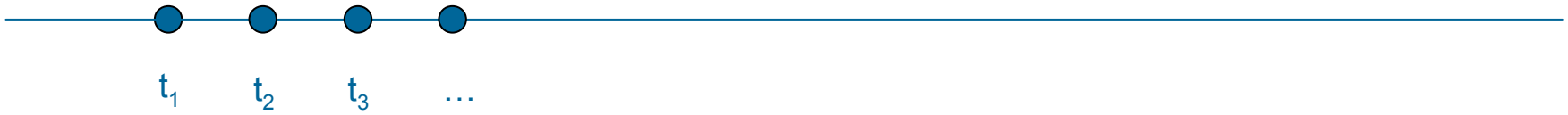
Examples of **non** proper interval



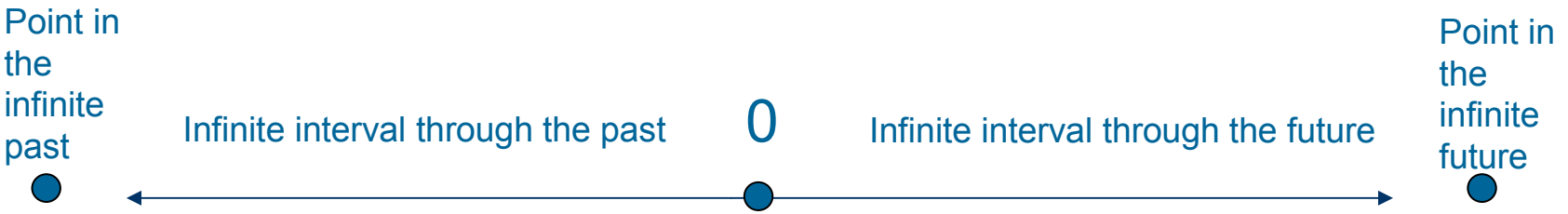
TIME MODELING NOTIONS. OPTIONAL EXTENSIONS (III)

Total ordering means that, for every pair of temporal points t_1 and t_2, necessarily $t_1 < t_2$ or $t_2 < t_1$.

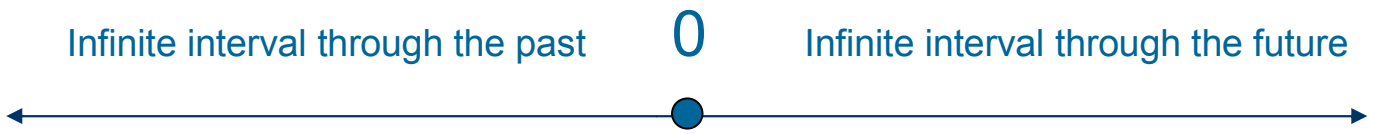
This feature eliminates models of time with branching futures and other conflations of time and possibility or limited knowledge.



Modelling of infinite. An infinite interval is that which is not limited in the past or in the future.



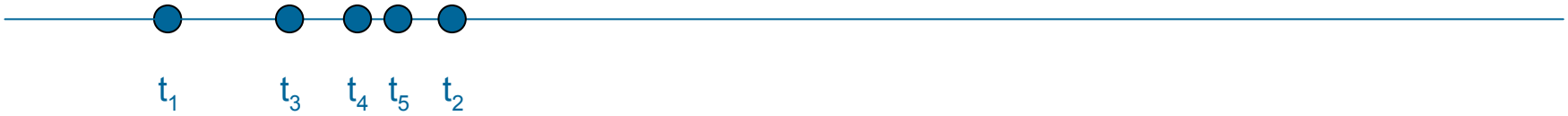
a) Interval with a point in the infinite past and a point in the infinite future



b) Infinite pass: intervals without left point. Infinite future: intervals without right point

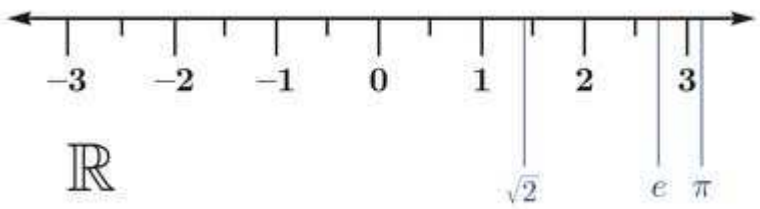
TIME MODELING. OPTIONAL EXTENSIONS (IV)

Density. which is used to represent that between any two distinct points there is a third distinct point.



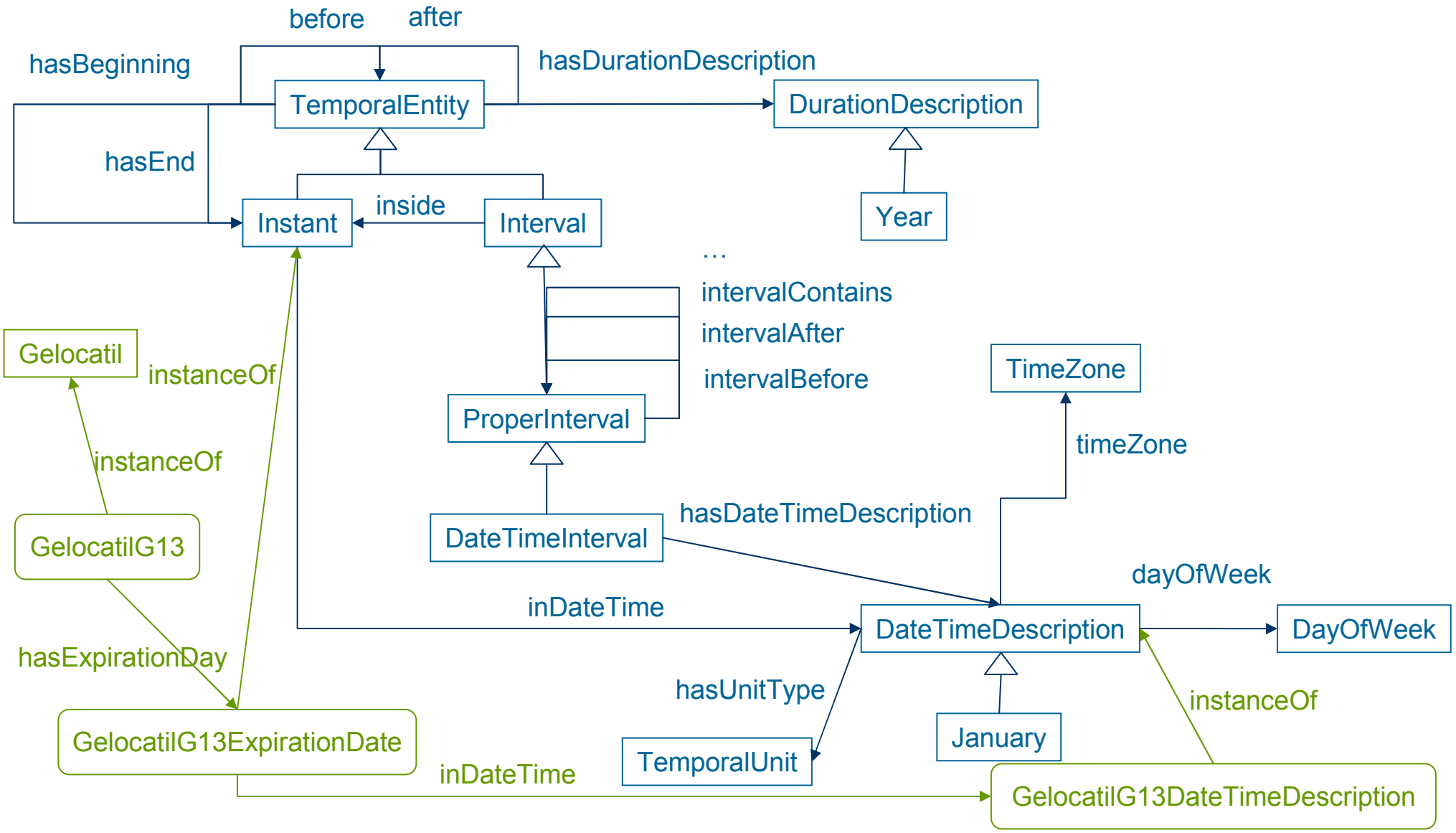
If we assume that between the second *s* and the second *s + 1* there is no another second, and the time is viewed as an ordered set of seconds, then density cannot be assumed.

Isomorphism to the real numbers. The set of real numbers is very often the model of the time theory.



http://dic.academic.ru/pictures/wiki/files/54/689px-real_number_line.svg.png

TIME OWL: EXAMPLE OF GENERAL ONTOLOGY



THE REUSE OF GENERAL ONTOLOGIES

1. Bibliography
2. The notion of general ontology
3. The reuse of general ontologies
   a. Why to reuse them?
   b. How to reuse them?

WHY TO REUSE GENERAL ONTOLOGIES?

1. Bibliography
2. The notion of general ontology
3. The reuse of general ontologies
   a. Why to reuse them?
   b. How to reuse them?

WHY TO REUSE GENERAL ONTOLOGIES?

Let's suppose now that we have to develop an ontology about pharmaceutical products in which we directly define an object property as 'isPartOf'.

In this case, to answer the CQ **'which medicament contains iron?'**, a Java program similar to this would be necessary

```
   // Java program JP1
   public static List<Individual> SearchForFeature(OntModel m, Individual initial,
ObjectProperty property, OntClass concept)
       {
           List<Individual> openL = new ArrayList();
           List<Individual> wholesL = new ArrayList();
           List<Individual> lIndividuals = new ArrayList();
           Iterator itc = concept.listInstances();
           while(itc.hasNext()) lIndividuals.add((Individual) itc.next());
           openL.add(initial);
           while (!openL.isEmpty())
           {
               Individual q = (Individual) openL.get(0);
               openL.remove(0);
               if (lIndividuals.contains(q)) wholesL.add(q);
               Iterator it = q.listPropertyValues( property );
               while(it.hasNext())
   openL.add(((OntResource) it.next()).asIndividual());
           }
           return wholesL;
       }
```

WHY TO REUSE GENERAL ONTOLOGIES?

However, if we are aware of the formal properties (e.g., transitivity, antisymmetry, etc.) of the relationship isPartOf and we include such formal notions in the ontology (e.g., transitivity), then the aforementioned CQ could be solved with this SPARQL query:

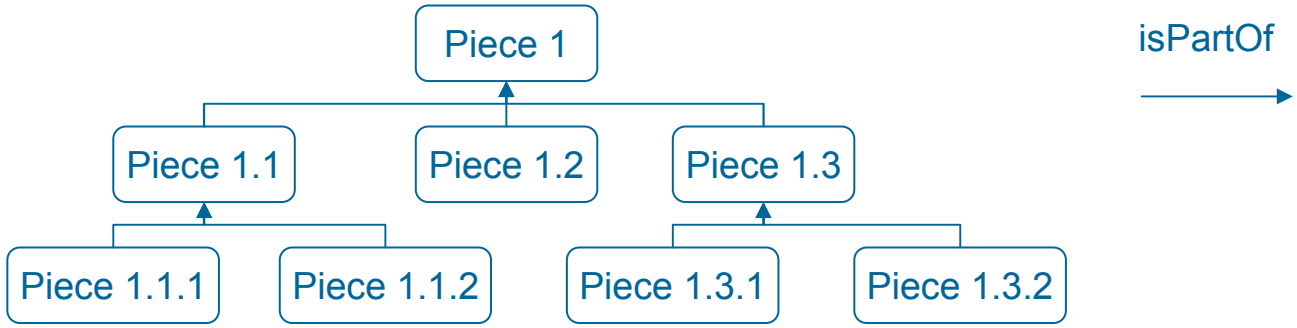
```
# SPARQL query SQ1
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX ub: <http://www.NewOnto1.org/killer201004271447#>
SELECT ?X
WHERE
{
        ?X rdf:type ub:drug .
        ub:iron ub:isPartOf ?X .
}
```

Procedural programming (e.g. Java) ⇨ How things are done

Declarative programming (e.g. OWL) ⇨ What things are ⇨ The reasoner works instead of developers

W3C MEREOLOGY USE CASES: INVENTORY OF PIECES IN A FACTORY

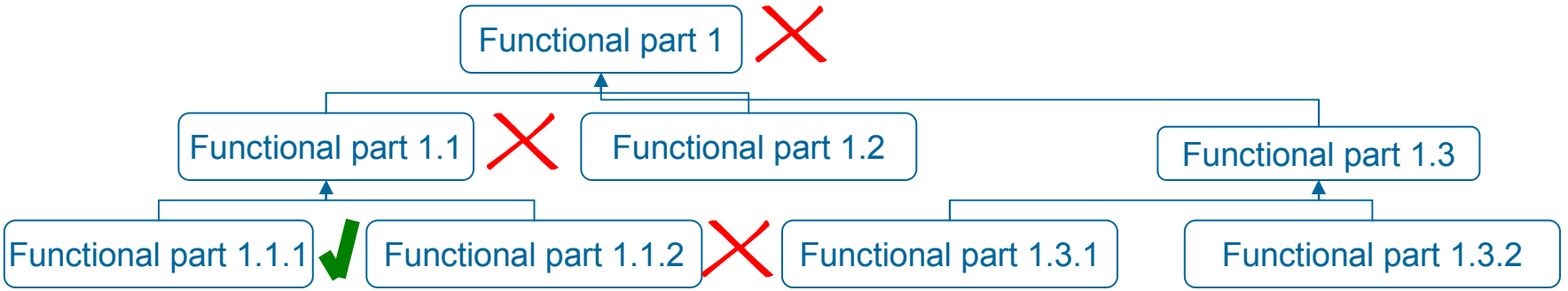
A parts inventory for the devices made in a factory in which we want to be able to find the "explosion" of parts required (i.e. for each part we can see the sub-parts).



Rector A, Welty C (eds), Noy N, Wallace E (contributors) (2005) *Simple part-whole relations in OWL Ontologies* . W3C Editors Draft (http://www.w3.org/2001/sw/BestPractices/OEP/SimplePartWhole/)

W3C MEREOLOGY USE CASES: FAULT FINDING SYSTEM

A fault finding system for a device in which we want to progressively narrow down the functional region of the fault.

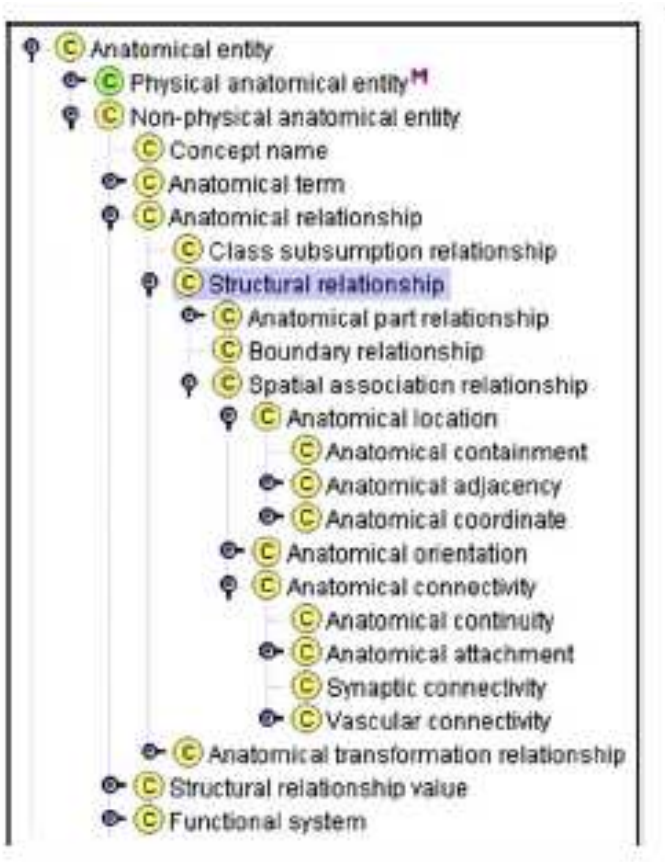


isPartOf →

Rector A, Welty C (eds), Noy N, Wallace E (contributors) (2005) *Simple part-whole relations in OWL Ontologies* . W3C Editors Draft (http://www.w3.org/2001/sw/BestPractices/OEP/SimplePartWhole/)

W3C MEREOLOGY USE CASES: ANATOMY MODEL

An anatomy representation such as the Digital Anatomist Foundational Model of Anatomy (*http://www.bioontology.org/*)



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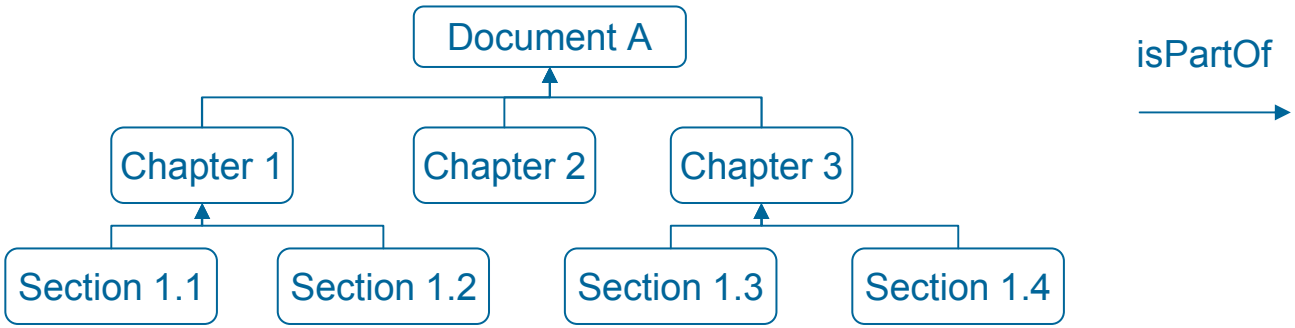
W3C MEREOLOGY USE CASES: DOCUMENT RETRIEVAL SYSTEM

A document retrieval system, in which documents are divided into chapters, sections, paragraphs etc.



Rector A, Welty C (eds), Noy N, Wallace E (contributors) (2005) *Simple part-whole relations in OWL Ontologies* . W3C Editors Draft (http://www.w3.org/2001/sw/BestPractices/OEP/SimplePartWhole/)

W3C TIME USE CASES: WEB SERVICES

Web services (e.g. air ticketing): a time ontology allow representing concepts like **CreditCardExpirationDate** and making inferences with them.

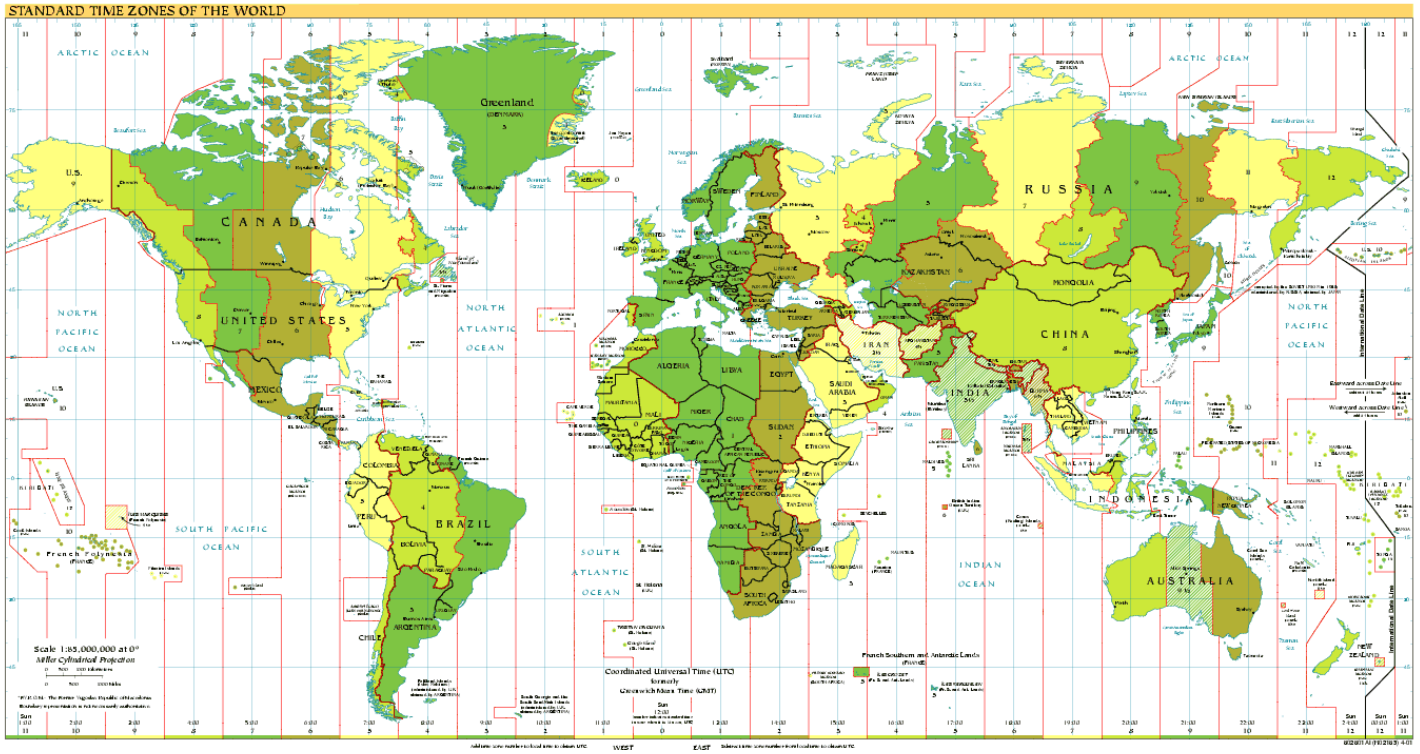
http://www.memory-srl.com.ar/img/como/3.jpg

Hobbs JR, Feng P (eds) (2006) *Time Ontologies in OWL*. W3C Working Draft 2. *http://www.w3.org/TR/owl-time/*

W3C TIME USE CASES: SCHEDULING

Suppose someone has a telecon scheduled for 6:00pm **EST** (Eastern Standard Time) on November 5, 2006. You would like to make an appointment with him for 2:00pm **PST** (Pacific Standard Time) on the same day, and expect the meeting to last 45 minutes. Will there be an overlap?

http://www.tagoror.com/enciclopedia/es/media/4/4b/timezones.png



Hobbs JR, Feng P (eds) (2006) *Time Ontologies in OWL*. W3C Working Draft 2. *http://www.w3.org/TR/owl-time/*

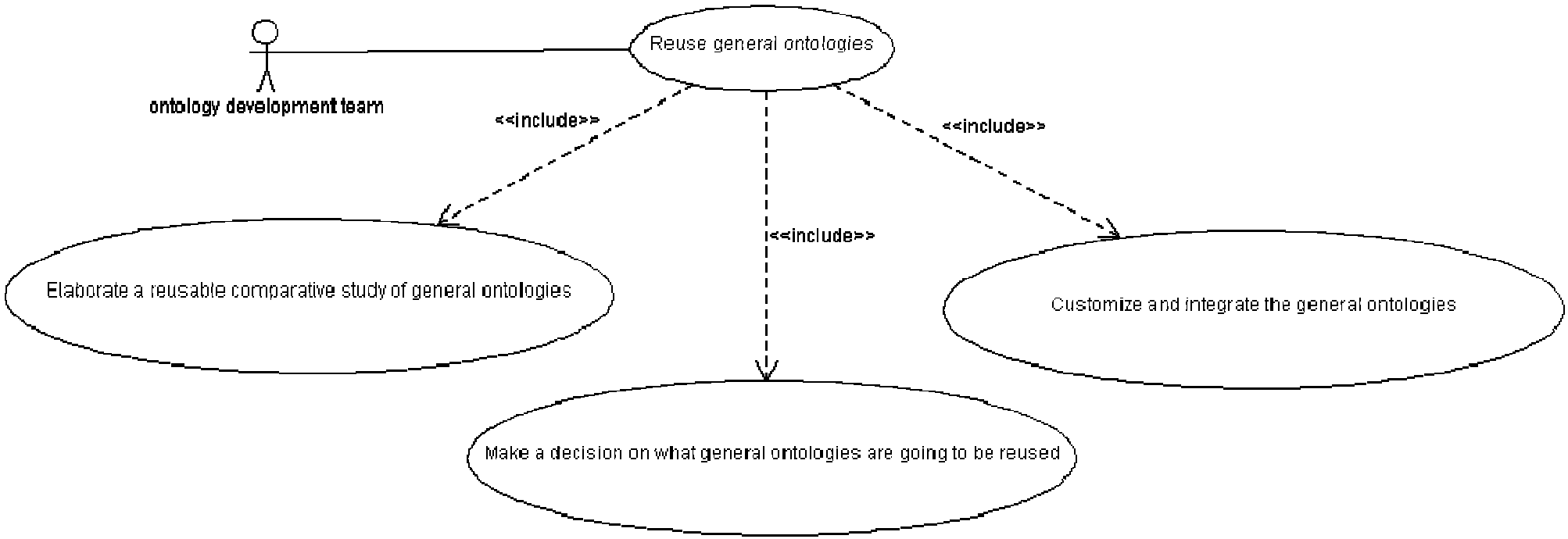
HOW TO REUSE GENERAL ONTOLOGIES

1. Bibliography
2. The notion of general ontology
3. The reuse of general ontologies
   a. Why to reuse them?
   b. How to reuse them?
   c. Conclusions
4. The work to be done by the student?

GUIDING EXAMPLE

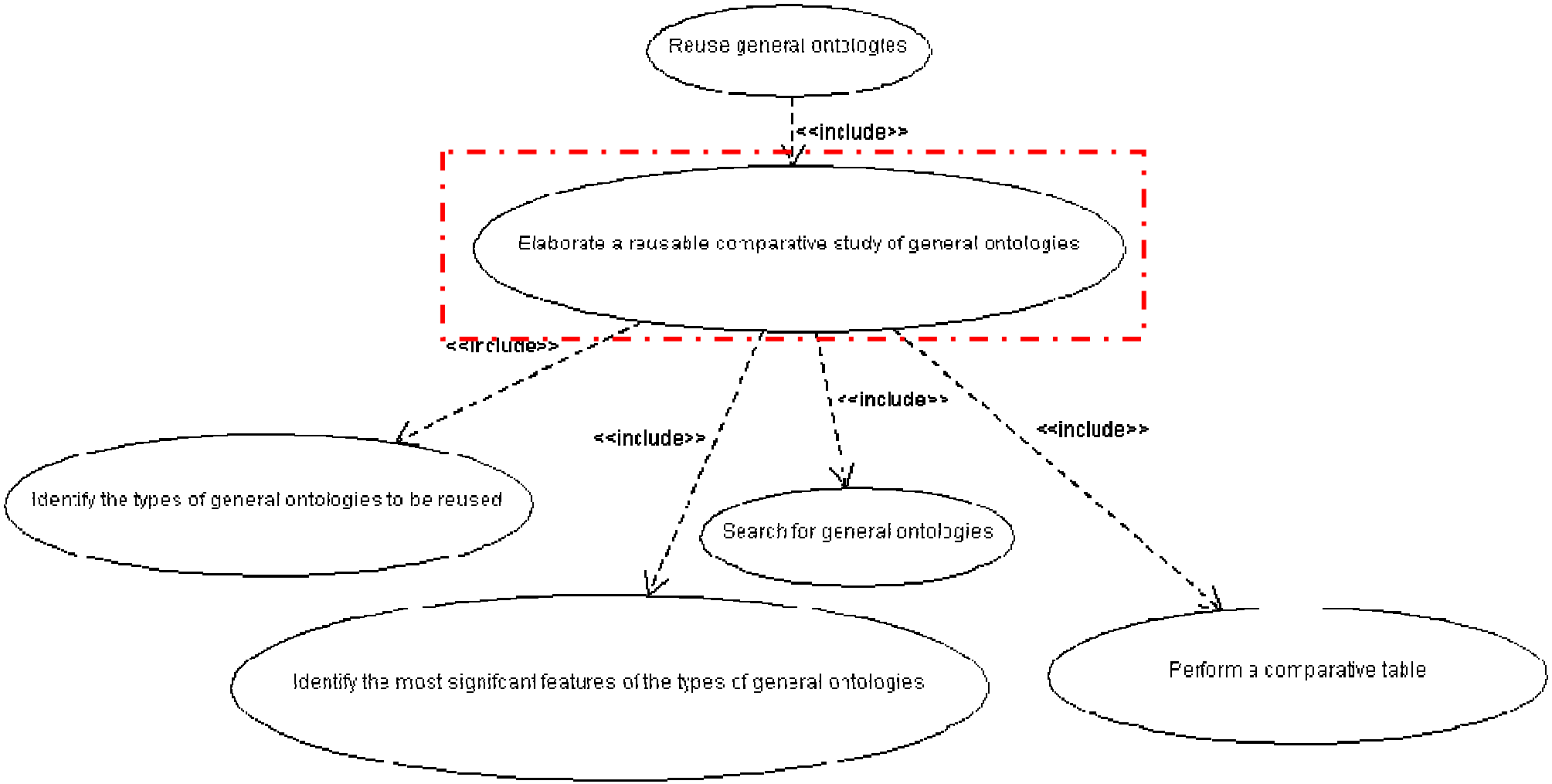
CQ id	Informal CQ	Example of answer
CQ1	What drugs do have paracetamol?	Algidol ® Apiretal ® Bisolgrip ® Cortafriol ® Dolgesic ® Dolostop ® Efferalgan ® Frenadol ® Gelocatil ® Pharmagrip ® Termalgin ®
CQ2	Which is the composition of Frenadol®?	Caffeine Chlorpheniramine citrate Dextrometorphan Paracetamol
CQ3	Which is the main active ingredient of Frenadol®?	Paracetamol
CQ4	Which substances does Frenadol® interact with?	Ethyl alcohol Isoniazid Propranolol Rifanpicin
CQ5	Which are the components of paracetamol?	Amino group, carbonyl group, carbon, hydrogen, nitrogen, etc.

HOW TO REUSE GENERAL ONTOLOGIES. USE CASES



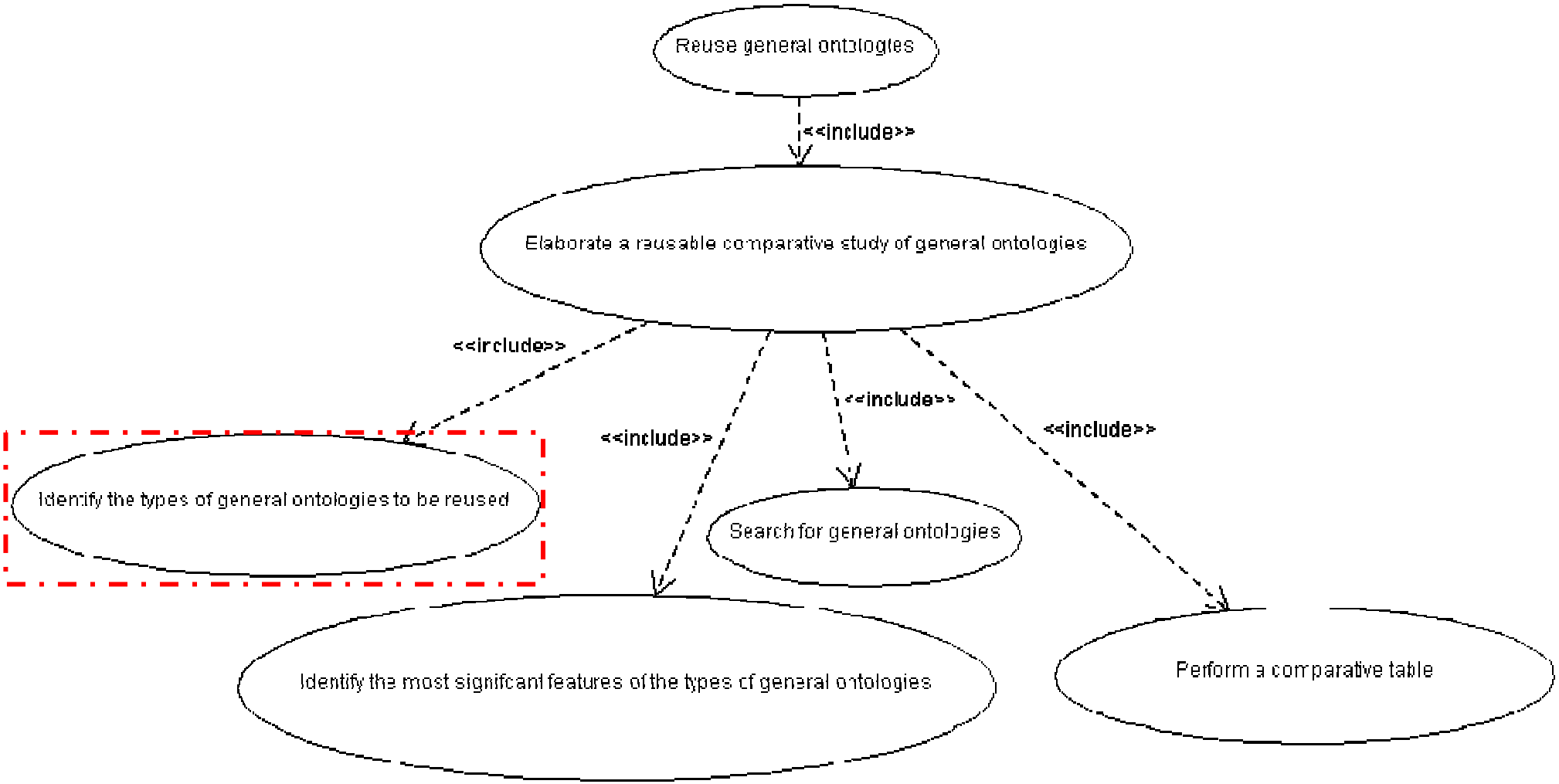
ArgoUML has been used to draw the UML diagrams of this presentation

ELABORATE A REUSABLE COMPARATIVE STUDY OF GENERAL ONTOLOGIES



ArgoUML has been used to draw the UML diagrams of this presentation

IDENTIFY THE TYPES OF GENERAL ONTOLOGIES TO BE REUSED

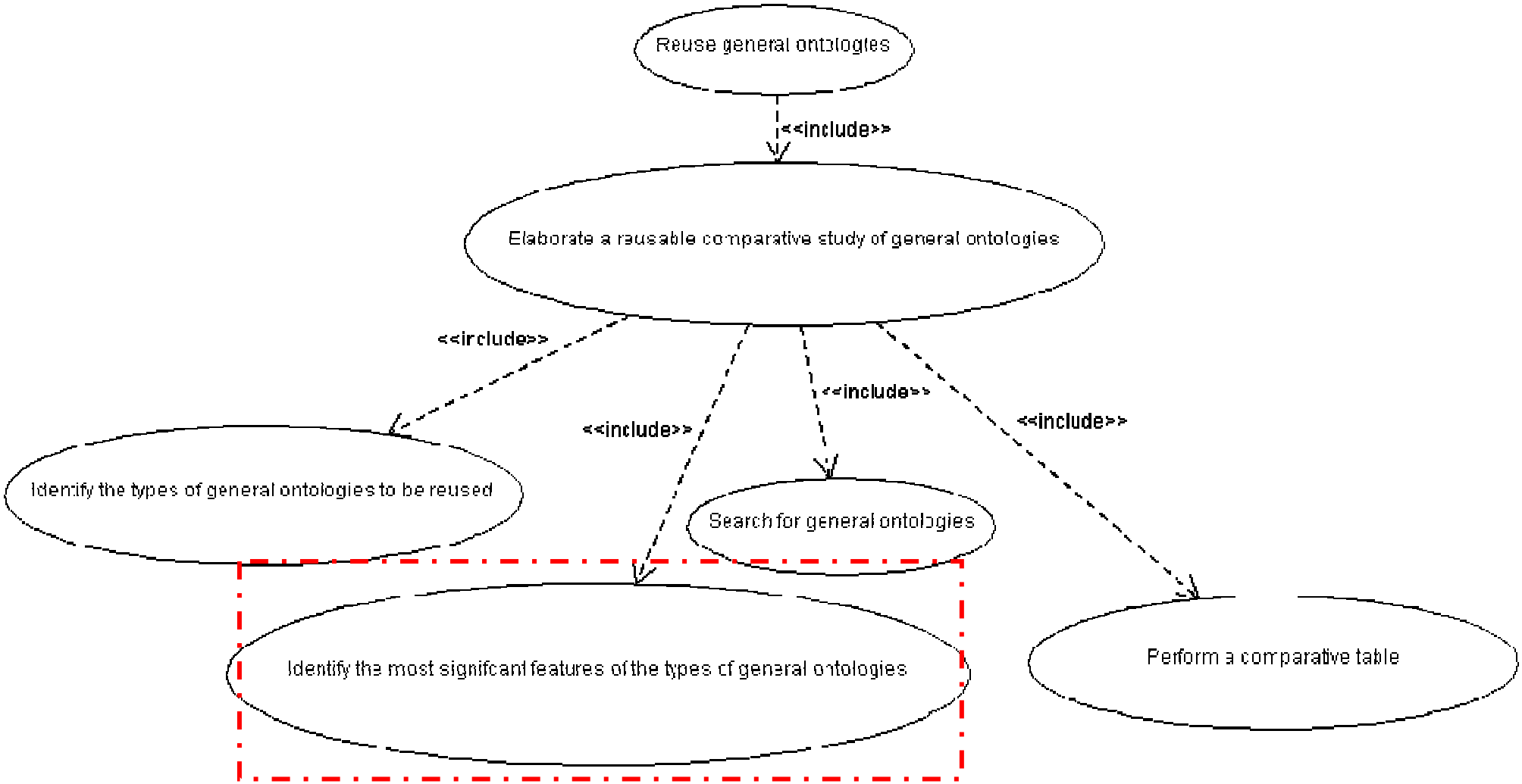


Based on Mariano Fernández-López, Asunción Gómez-Pérez and Mª Carmen Suárez Figuereoa's work

IDENTIFYING THE TYPE OF GENERAL ONTOLOGY TO BE REUSED

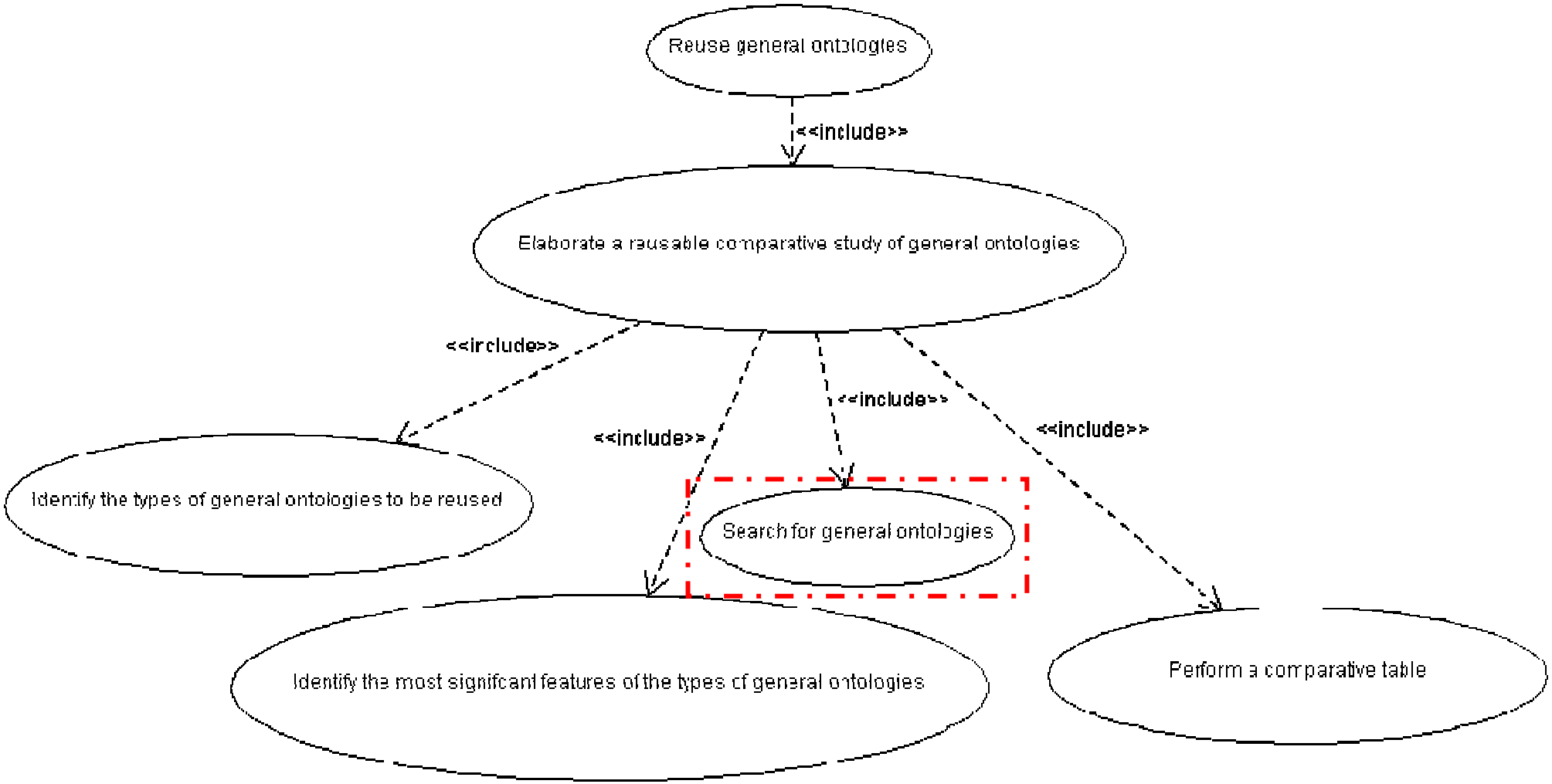
Condition on the CQs of the ontology	Typical cases	*Type of general ontology to reuse*
A reference to time appears.	The word ***when*** appears (e.g. When is the deadline for applying to the Young Talent Competition?).	***Time modeling***
	Some of the following adverbs appears: ***after***, ***before*** (e.g. Is Avelina Vidal's concert held before the Ciclo Excelentia activity?), ***at the same time***, ***simultaneously***, etc.	
	The expressions following terms appear: ***how many times***, ***how much time***, ***how often*** (e.g. How often are performances held at the Royal Theatre of Madrid?), etc..	
	Some of the following nouns appears: ***date***, ***hour*** (e.g. How many hours does the *Salome* opera last?), ***minute***, ***second***, etc.	
	Etc.	
The conjunction of the following conditions is satisfied: CM_1) the CQ refers to a relation *R* that establishes an order; and CM_2) *R* fulfils the weak supplementation principle.	**Spatial relations** (e.g. Which places can be visited in the Netherlands?)	***Mereology***
	Relations between activities (e.g. Which are the parts of Avelina Vidal's concert?)	
	Relations between mechanical devices and their pieces (e.g. Which are the pieces of Citroën 2CV?)	
	Etc.	
CM_3) The CQ refers to a relation S *that is sub-relation of an* R *that satisfies conditions CM_1 and CM_2.*	**Some sub-relations in the aforementioned domains** (for instance, is capital of, is the conductor of, is the main component of, etc.). An example of CQ fulfilling this condition is Which is the capital of country C?	

IDENTIFY THE MOST SIGNIFICANT FEATURES OF THE TYPES OF GENERAL ONTOLOGIES



They have been already shown in this presentation

SEARCH FOR GENERAL ONTOLOGIES



SEARCHING FOR ONTOLOGIES

We can use:

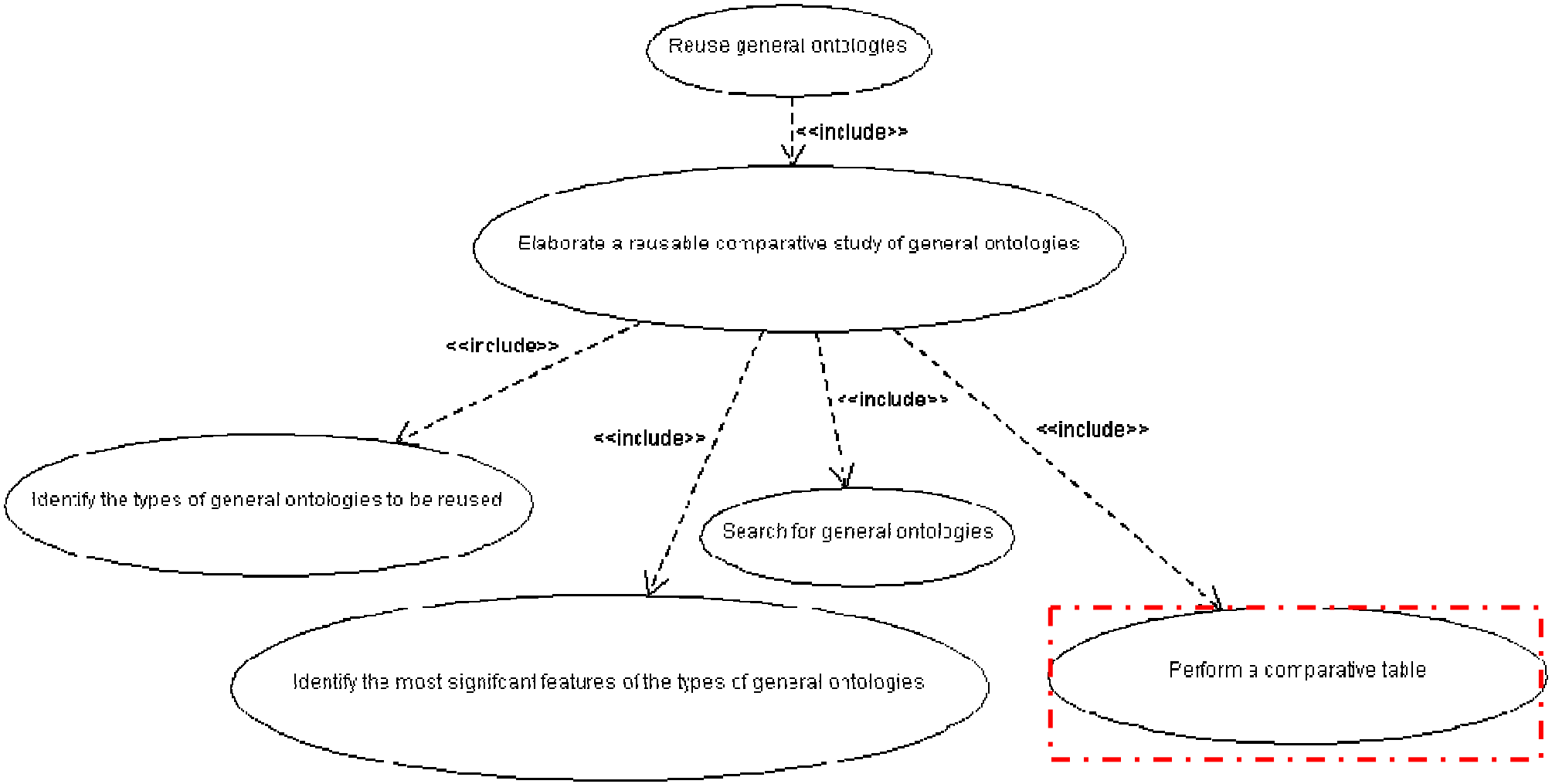
- **general purpose search engines** (e.g. Google);

- **search engines for ontologies** (e.g. Swoogle and Watson);

- **repositories** (e.g. Protégé ontology library and the Open Biological and Biomedical Ontologies);
- **known ontologies** (for instance, mereology terms can be reused from Dolce-Lite , SUMO-OWL , etc.).

Found mereology implementations	*Project or institution*	URL
Single part whole	*W3C*	http://www.w3.org/2001/sw/BestPractices/OEP/SimplePartWhole/part.owl
SUMO-OWL	*IEEE Standard Upper Ontology working group*	http://www.ontologyportal.org/translations/SUMO.owl.txt
Dolce-Lite	*Italian Research Council (CNR)*	http://www.loa-cnr.it/ontologies/DOLCE-Lite.owl
Oswebsite	*OS Open data*	http://www.ordnancesurvey.co.uk/oswebsite/ontology/Mereology.owl
OBO	*Open Biological and Biomedical Ontologies*	http://www.berkeleybop.org/ontologies/obo-all/relationship/relationship.owl

PERFORM A COMPARATIVE TABLE



PERFORM A COMPARATIVE TABLE. MEREOLOGY

Possible values for axioms: *yes* or *no*
Possible values for definitions: *heavy*, *light* or *no*.

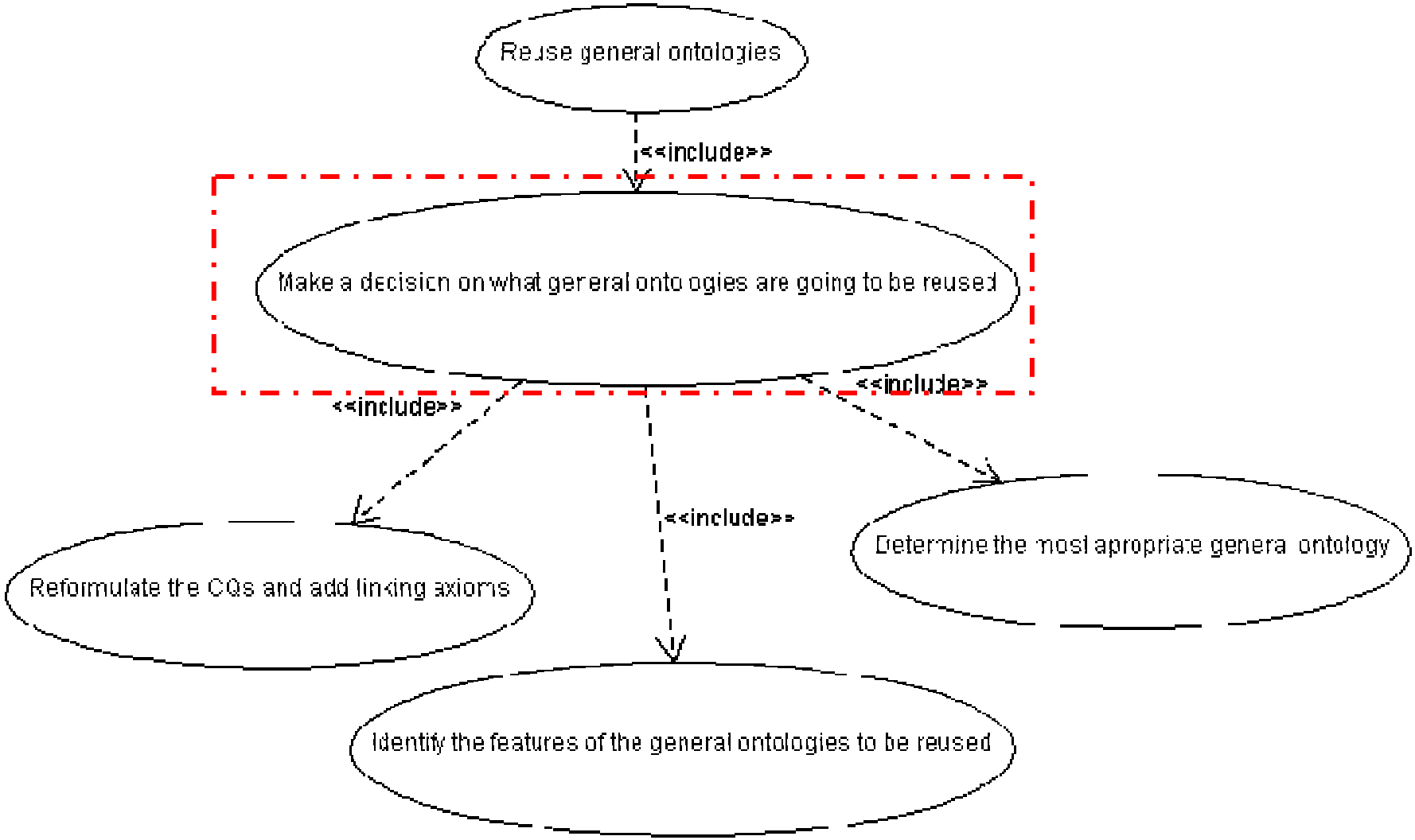
Axioms and definitions	Single part whole	SUMO-OWL	Dolce-Lite	Oswebsite	OBO
A.1) Reflexivity					
A.2) Antisymmetry					
A.3) Transitivity	Yes		Yes	Yes	Yes
D.1) Proper part		Light	Light		Light
D.2) Direct part	Light			Light	
D.3) Overlap		Light	Light		
D.4) Underlap					
D.5) Disjoint					
A.4) Weak supplementation					

The term appear in the ontology, but no explicit definition (≡) is provided

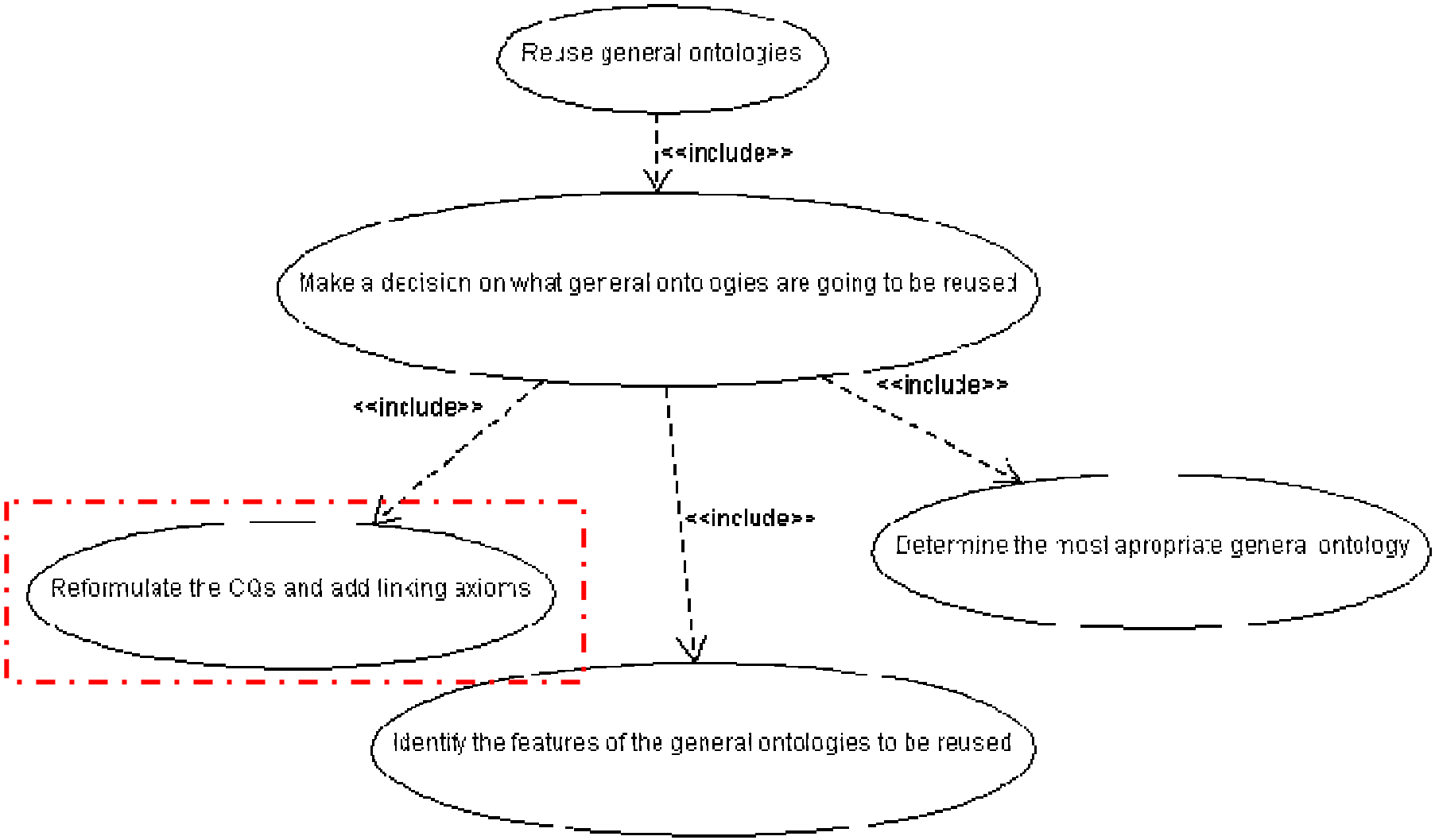
PERFORM A COMPARATIVE TABLE. TIME MODELING

Features required / features provided	OWL-Time	SUMO-OWL	AKT-Time
Time points	Light	Light	Light
Time intervals	Light	Light	Light
Absolute time	Light		Light
Relations between temporal entities	Light	Light	
Modeling of convex intervals	Light	Light	
Modeling of non convex intervals			
Modeling of open intervals			
Modeling of closed intervals	Light	Light	
Explicit modelling of proper intervals	Light		
Modeling of different temporal granularities	Light	Light	Light
Modeling of different time zones	Light		
Modeling of total ordering			
Modeling of infinity		Light	
Density			
Isomorphism to the real numbers			

MAKE A DECISION ON WHAT GENERAL ONTOLOGIES ARE GOING TO BE REUSED



REFORMULATE THE CQs AND ADD LINKING AXIOMS



HEURISTICS TO ANALYZE AND TRANSFORM THE CQs AND ADD LINKING AXIOMS AND RULES FOR MEREOLOGY REUSE

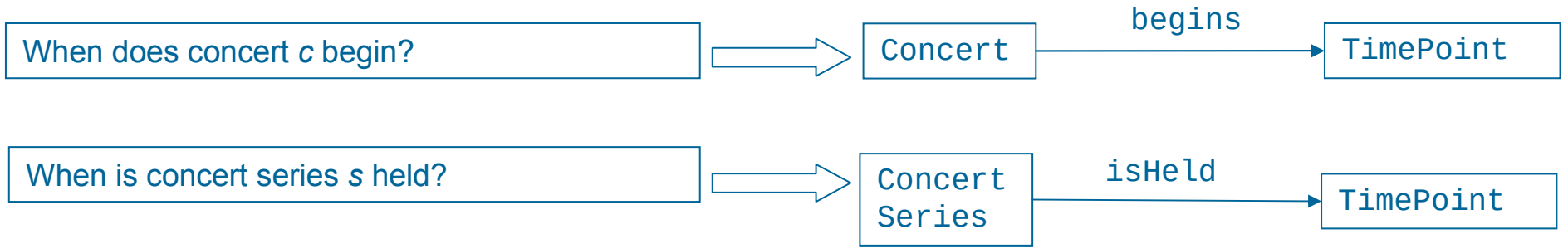
Condition on the CQs of the ontology	Case	Action to carry out
CM_1 and CM_2 are fulfilled	CsM_1) We are interested in knowing if two objects have **common parts**.	To reformulate the CQ so that the term ***overlap*** appears.
	CsM_2) We want to know if two objects have **common wholes**.	To reformulate the CQ so that the term ***underlap*** appears.
	CsM_3) We want to know **the parts of an object excluding the object itself**.	To reformulate the CQ so that the term ***proper part of*** appears.
	CsM_4) We want to know **the direct parts of an object**.	To reformulate the CQ so that the term ***is direct part of*** appears.
	CsM_5) We want to know **the parts of an object, including the object itself**. A typical case is that in which the mereological relation appears in a composition of relations.	To reformulate the CQ so that the term ***is part of*** appears.
	CsM_6) We want to know **which parts of object o_1 are not in object o_2**.	To reformulate the CQ so that the term ***are disjoint*** appears.
CM_3 is fulfilled	CsM_7) We have applied CM_3 in all the cases in which the condition has been fulfilled.	To introduce a linking axiom establishing that *S* is sub-relation of *is part of*.

EXAMPLES

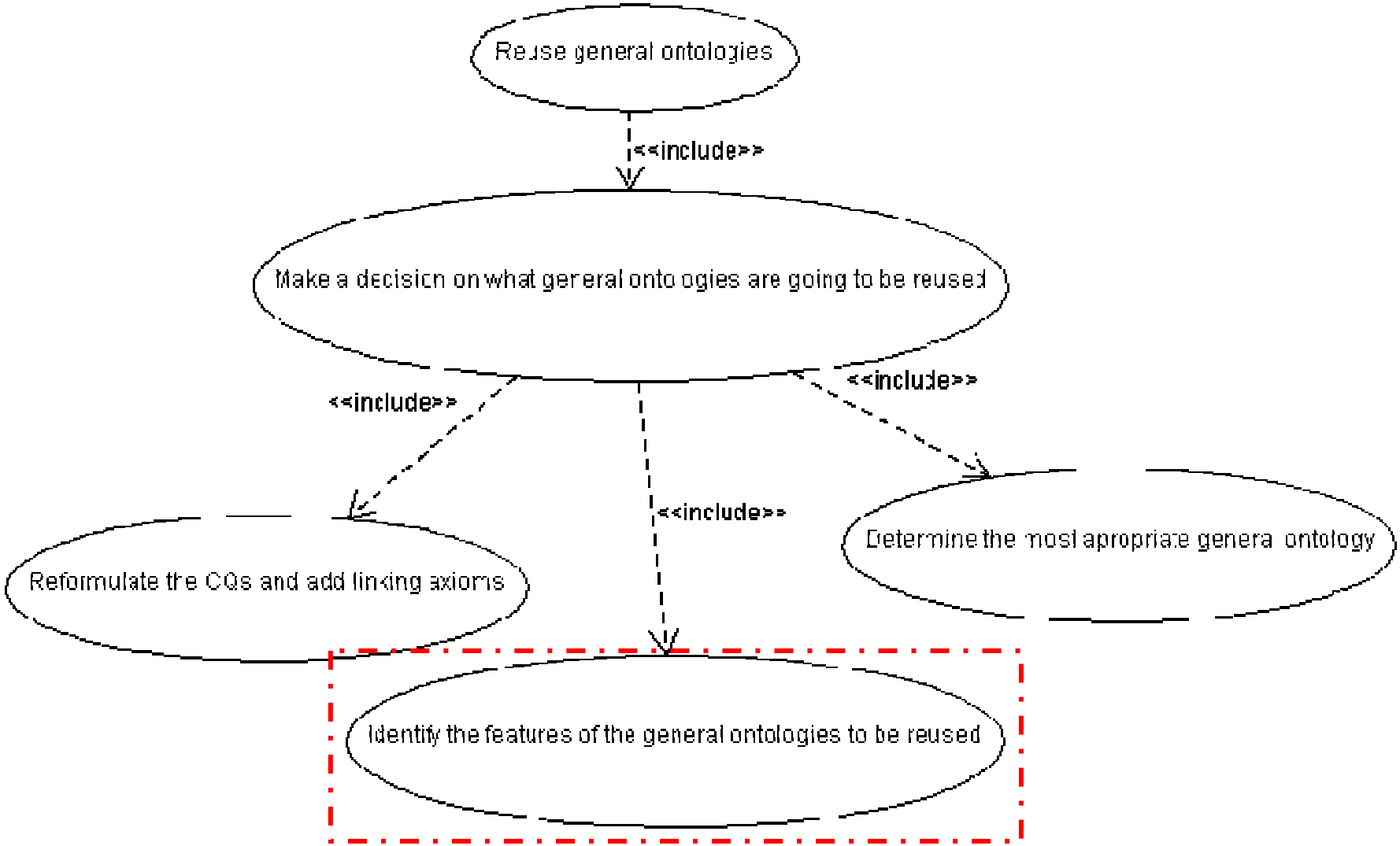
Do the Nordic Countries and the EU have parts in common?	⇒	Do the Nordic Countries and the EU **overlap**?
Do Belgium and Luxemburg belong to common organizations?	⇒	Do Belgium and Luxemburg **underlap**?
Which are the countries, provinces, cities, towns, etc. of Benelux?	⇒	Which are the **proper parts** of Benelux?
Which are the countries of Benelux?	⇒	Which are the **direct parts** of Benelux?
Does Avelina Vidal perform in Madrid?	⇒	Does Avelina Vidal perform in **some part of** Madrid?
Which provinces of the Netherlands do not belong to Holland?	⇒	Which provinces of the Netherlands are **disjoint** with Holland?
Which is the capital of the country?	⇒	`isPartOf` ← `isCapitalOf`

HEURISTICS TO ANALYZE AND TRANSFORM THE CQs AND ADD LINKING AXIOMS AND RULES FOR TIME MODELING

Condition that satisfies the CQs of the ontology	Case	Action to carry out
CT_1) We have ignored which are the extremes of the temporal entity returned by the CQ.	Time points	Introduce a linking axiom to time points.
CT_2) We have ignored which are the extremes of the temporal entity returned by the CQ.	Time intervals	Introduce a linking axiom to time intervals.



IDENTIFY THE FEATURES OF THE GENERAL ONTOLOGIES TO BE REUSED



HEURISTICS TO IDENTIFY DEFINITIONS TO BE REUSED

If a term is generated in the transformation of CQs, then its definition should be reused

Do the Nordic Countries and the EU have parts in common? ⇒ Do the Nordic Countries and the EU **overlap**?

When does concert *c* begin? ⇒ `Concert` —`begins`→ `TimePoint`

HEURISTICS TO IDENTIFY MEREOLOGY AXIOMS TO BE REUSED

Axioms and definitions	When they are useful	Clarifying examples
A.1) *Is part of* reflexivity	Recommended to ensure the right meaning of *part of*.	It allows a right work for `interactsWith(?x, ?y), part(?x, ?z) -> interactsWith(?z, ?y)`
A.2) *Is part of* antisymmetry	Recommended for consistency verification.	Fact 1: "Frenadol®, Gelocatil®, paracetamol, etc. are all different". Fact 2: "Paracetamol is part of Frenadol" Anstisymmetry prevents Wrong fact: "Frenadol® is part of paracetamol"
A.3) *Is part of* transitivity	*X* has parts $X_1, X_2, \ldots, X_n$. In its turn, there is some *X*i with parts $X_{i1}, X_{i2}, \ldots, X_{im}$. That is, ***X* has several levels of parts**. Besides, we are interested in all the levels when we ask: *which are the parts of X?*	It allows a right work for `interactsWith(?x, ?y), part(?x, ?z) -> interactsWith(?z, ?y)`
A.4) *Is part of* weak supplementation	Recommended for consistency verification.	It prevents this type of mistake in the cardinality: "The only proper part of Frenadol® is paracetamol."

Based on Mariano Fernández-López, Asunción Gómez-Pérez and Mª Carmen Suárez Figuereoa's work

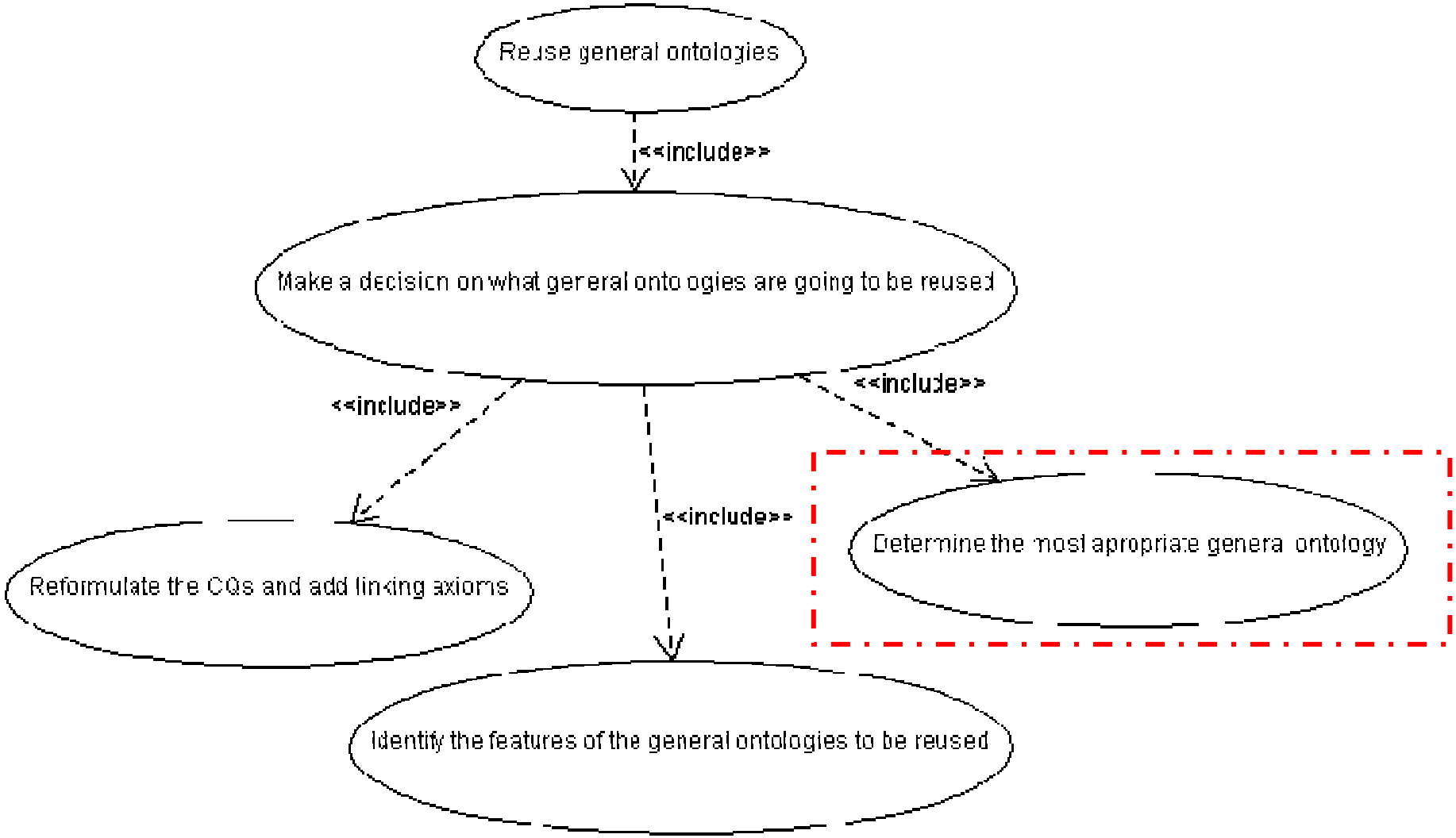
REUSABLE FEATURES OF EACH GENERAL ONTOLOGY

Possible values for axioms: *yes* or *no*
Possible values for definitions: *heavy*, *light* or *no*.

Functional features	A.1) Reflexivity	A.2) Antisymmetry	A.3) Transitivity	D.1) Proper part	A.4) Weak supplementation
Single part whole	[no]	[no]	[yes]	[no]	[no]
SUMO-OWL	[no]	[no]	[no]	[light]	[no]
Dolce-Lite	[no]	[no]	[yes]	[light]	[no]
Oswebsite	[no]	[no]	[yes]	[no]	[no]
OBO	[no]	[no]	[yes]	[light]	[no]

Based on Mariano Fernández-López, Asunción Gómez-Pérez and Mª Carmen Suárez Figuereoa's work

IDENTIFY THE FEATURES OF THE GENERAL ONTOLOGIES TO BE REUSED



MULTI-FCA ANALYSIS. CONTENT FEATURES

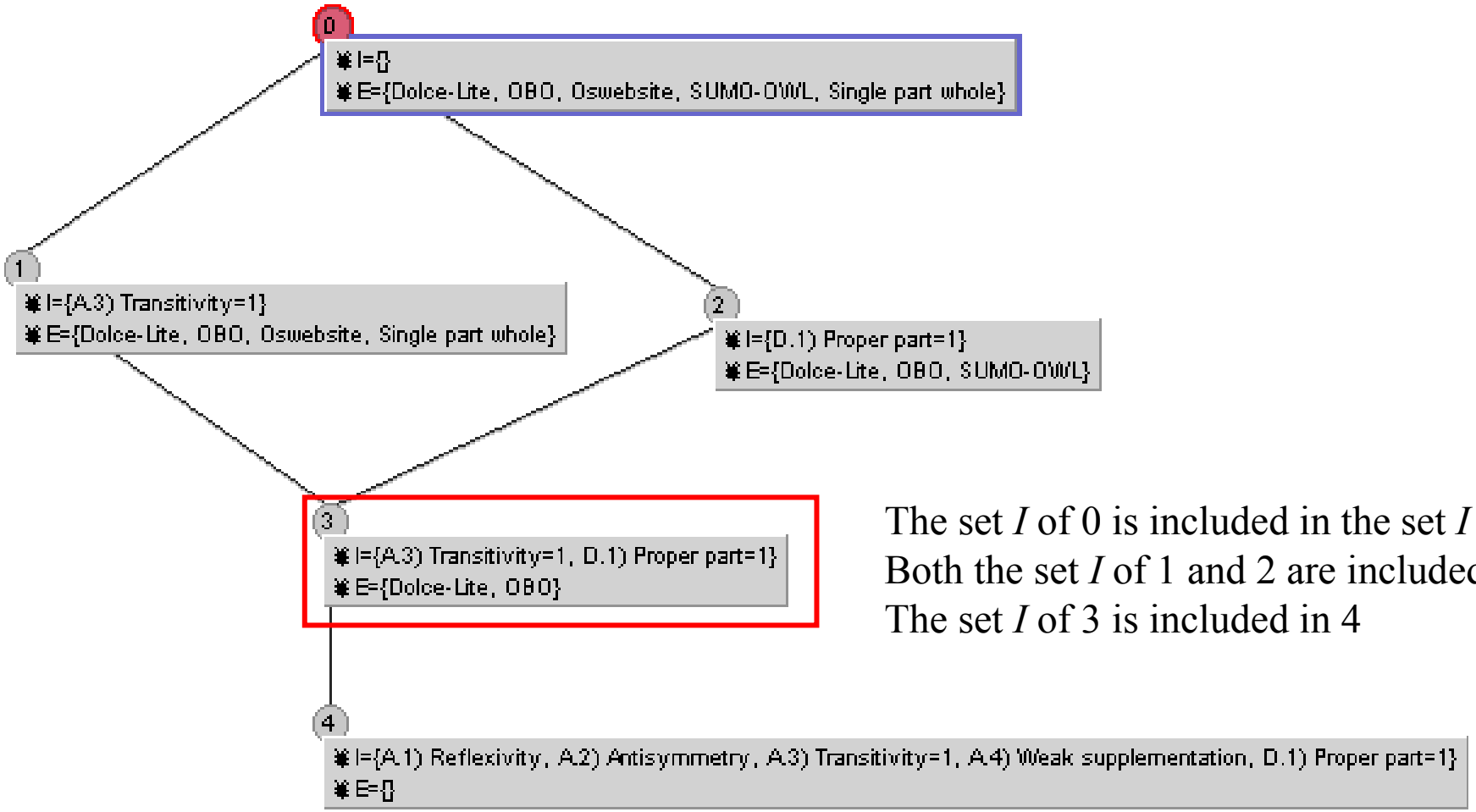
Functional features	A.1) Reflexivity	A.2) Antisymmetry	A.3) Transitivity	D.1) Proper part	A.4) Weak supplementation
Single part whole	[no]	[no]	[yes]	[no]	[no]
SUMO-OWL	[no]	[no]	[no]	[light]	[no]
Dolce-Lite	[no]	[no]	[yes]	[light]	[no]
Oswebsite	[no]	[no]	[yes]	[no]	[no]
OBO	[no]	[no]	[yes]	[light]	[no]

Possible values for axioms: *yes* = [1] or *no* = 0.
Possible values for definitions: *heavy* = [1, 2], *light* = [1] or *no* = 0.

Functional f...	A.1) Reflexi...	A.2) Antisy...	A.3) Transit...	D.1) Proper...	A.4) Weak ...
Single part ...	0	0	[1]	0	0
SUMO-OWL	0	0	0	[1]	0
Dolce-Lite	0	0	[1]	[1]	0
Oswebsite	0	0	[1]	0	0
OBO	0	0	[1]	[1]	0

We only know how to transform the values by hand. Therefore, the best option seems to be to omit the version with values *yes*, *no*, etc. and directly write the version with values [1], 0, etc.

MULTI-FCA ANALYSIS. CONTENT FEATURES (LATTICE)

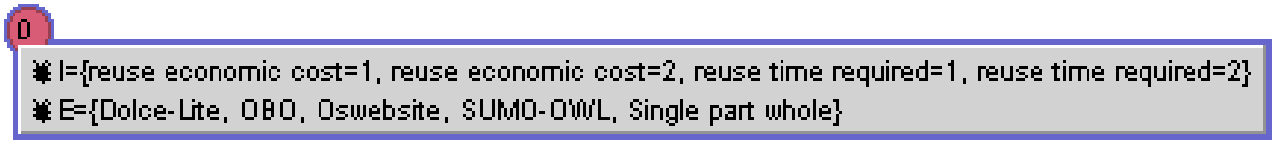


The set *I* of 0 is included in the set *I* of 1.
Both the set *I* of 1 and 2 are included in 3.
The set *I* of 3 is included in 4

MULTI-FCA ANALYSIS. REUSE COST

A	B	C
Reuse cost	reuse economic cost	reuse time required
Single part ...	[1, 2]	[1, 2]
SUMO-OWL	[1, 2]	[1, 2]
Dolce-Lite	[1, 2]	[1, 2]
Oswebsite	[1, 2]	[1, 2]
OBO	[1, 2]	[1, 2]

Possible values: *low* (the worst result) = 0,
unknown = [1],
medium = [1],
or *high* (the best result) = [1, 2].



- *Reuse Cost*. It refers to the estimate of the cost (economic and temporal) needed for the reuse of the candidate ontology. In this case, the following criteria should be analyzed:
  - *Reuse Economic Cost*. It refers to the estimate of the economic cost needed for accessing and using the candidate ontology. If the candidate ontology has any type of license, then the cost of acquisition and/or exploitation should be taken into account.
  - *Reuse Time Required*. It refers to the estimate of the time required for accessing the candidate ontology. If the candidate ontology is accessible in slow servers or in servers with bad connectivity, the time spent in accessing should be considered.

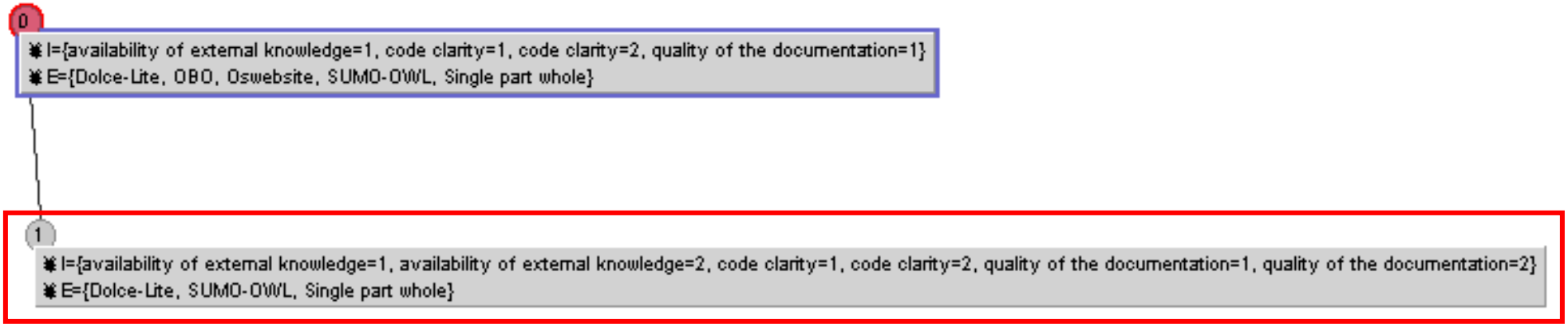
MULTI-FCA ANALYSIS. UNDERSTANDABILITY EFFORT (I)

- *Understandability Effort*. It refers to the estimate of the effort needed for understanding the candidate ontology. In this case, the following criteria should be analyzed:
  - *Quality of the documentation*. It refers to whether there is any communicable material to describe or explain different aspects of the candidate ontology (e.g., modelling decisions). The documentation should explain the knowledge pieces represented in the ontology, so that a non-expert could understand the knowledge represented in it.
  - *Availability of external knowledge sources*. It refers to whether the candidate ontology has references to documentation sources, and whether experts are easily available.
  - *Code clarity*. It refers to whether the code is ease to understand and modify, that is, if the knowledge entities follow unified patterns and if patterns are clear. It is convenient to use the same pattern to make sibling definitions, thus increasing ontology understanding and making it easier the inclusion of new definitions. All of which would improve the clarity of the ontology and its monotonic extendibility. *Code clarity* also refers to whether the code is documented, that is, if it includes clear and coherent definitions and comments for the knowledge entities represented in the candidate ontology.

Based on Mariano Fernández-López, Asunción Gómez-Pérez and Mª Carmen Suárez Figuereoa's work

MULTI-FCA ANALYSIS. UNDERSTANDABILITY EFFORT (II)

A	B	C	D
Understandability effort	quality of the documentation	availability of external knowledge	code clarity
Single part whole	[1, 2]	[1, 2]	[1, 2]
SUMO-OWL	[1, 2]	[1, 2]	[1, 2]
Dolce-Lite	[1, 2]	[1, 2]	[1, 2]
Oswebsite	[1]	[1]	[1, 2]
OBO	[1]	[1]	[1, 2]



Based on Mariano Fernández-López, Asunción Gómez-Pérez and Mª Carmen Suárez Figuereoa's work

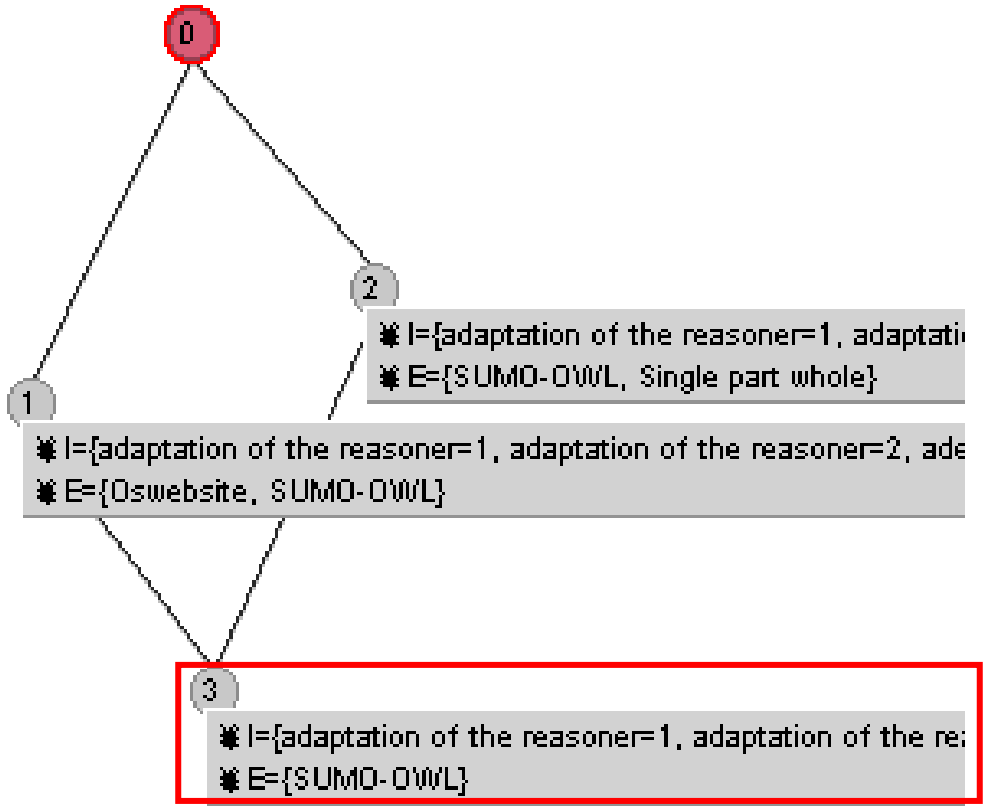
MULTI-FCA ANALYSIS. INTEGRATION EFFORT (I)

- *Integration Effort*. It refers to the estimate of the effort needed for integrating the candidate ontology into the ontology being developed. In this case, the following criteria should be analyzed:
  - *Adequacy of knowledge extraction*. It refers to whether it is easy to identify parts of the candidate ontology to be reused and to extract them. For example, in large and not modularized ontologies (e.g. SUO) it is extremely difficult to extract the part of the knowledge we are interested in.
  - *Adequacy of naming conventions*. It refers to whether both ontologies (the candidate and the one being developed) follow the same rules for naming the different ontology components (e.g., concept names should start with capital letters, relation names should start with non-capital letters).
  - *Adequacy of the implementation language*. It refers to whether both languages (the candidate ontology's and the ontology's being developed) are the same, or at least are able to represent similar knowledge with the same granularity.
  - *Knowledge clash*. It refers to whether there are contradictory bits of knowledge between the candidate ontology to be reused and the ontology being developed (e.g., having density in a time ontology and requiring no density in the ontology being developed).
  - *Adaptation to the reasoner*. It refers to whether the adaptation of definitions and axioms that satisfy the existing restrictions of the reasoner are needed (e.g., explicit definitions can be included in OWL ontologies; however, this kind of definitions can not be included in ontologies written in Prolog).
  - *Necessity of bridge terms*. It refers to whether it is necessary to create new linking axioms and/or relations to integrate the candidate ontology to be reused into the ontology being developed.

Based on Mariano Fernández-López, Asunción Gómez-Pérez and Mª Carmen Suárez Figuereoa's work

MULTI-FCA ANALYSIS. INTEGRATION EFFORT (II)

A	B	C	D	E	F	G
Integration effort	adequacy of knowledge extraction	adequacy of naming conventions	adequacy of the implementation language	knowledge clash	adaptation of the reasoner	necessity of bridge terms
Single part whole	[1, 2]	0	[1, 2]	[1, 2]	[1, 2]	[1, 2]
SUMO-OWL	[1, 2]	[1, 2]	[1, 2]	[1, 2]	[1, 2]	[1, 2]
Dolce-Lite	0	0	[1, 2]	[1, 2]	[1, 2]	[1, 2]
Oswebsite	0	[1, 2]	[1, 2]	[1, 2]	[1, 2]	[1, 2]
OBO	0	0	[1, 2]	[1, 2]	[1, 2]	[1, 2]



Based on Mariano Fernández-López, Asunción Gómez-Pérez and Mª Carmen Suárez Figuereoa's work

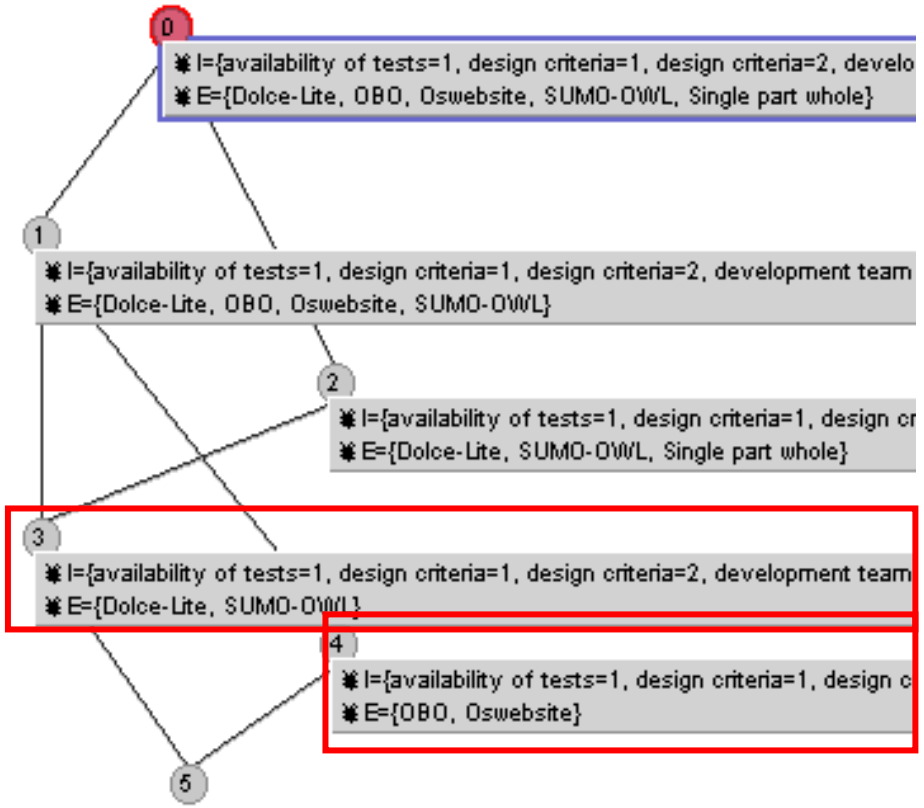
MULTI-FCA ANALYSIS. RELIABILITY (I)

- *Reliability*. It refers to whether we can trust the candidate ontology to be reused. In this case, the following criteria should be analyzed:
  - *Design criteria*. It refers to whether the ontology has been built according to the design criteria assumed by the development team of the domain ontology.
  - *Availability of tests*. It refers to whether tests are available for the candidate ontology to be reused.
  - *Former evaluation*. it refers to whether the ontology has been properly evaluated, which here means that there is a set of unit tests that the ontology passed.
  - *Theoretical support*. It refers to whether the candidate ontology is supported by a contrasted theory.
  - *Development team reputation*. It refers to whether the development team of the candidate ontology is reliable.
  - *Purpose reliability*. It refers to whether the candidate ontology has been developed as a simple academic example.
  - *Practical support*. It refers to whether there are well known projects or ontologies reusing the candidate ontology.

Based on Mariano Fernández-López, Asunción Gómez-Pérez and Mª Carmen Suárez Figuereoa's work

MULTI-FCA ANALYSIS. RELIABILITY (II)

A	B	C	D	E	F	G	H
Reliability	design criteria	availability of tests	former evaluation	theoretical support	development team reputation	purpose reliability	practical support
Single part ...	[1, 2]	[1]	[1]	[1, 2]	[1, 2]	0	[1]
SUMO-OWL	[1, 2]	[1]	[1]	[1, 2]	[1, 2]	[1]	[1]
Dolce-Lite	[1, 2]	[1]	[1]	[1, 2]	[1, 2]	[1]	[1]
Oswebsite	[1, 2]	[1]	[1]	[1]	[1, 2]	[1, 2]	[1]
OBO	[1, 2]	[1]	[1]	[1]	[1, 2]	[1, 2]	[1]



Based on Mariano Fernández-López, Asunción Gómez-Pérez and Mª Carmen Suárez Figuereoa's work

COMPARISON OF THE FCA RESULTS

MEREOLOGY AXIOMS AND DEFINITIONS

Requires a low effort

Dolce-Lite and OBO formalices transitivity of `isPartOf` and has a term for `isProperPartOf`, but it does not provides an explicit definition.

REUSE COST

The reuse cost does not decide.

UNDERSTANDABILITY EFFORT

Dolce-Lite, SUMO-OWL and Single Part Whole have a high quality of the documentation and high availability of external knowledge.

INTEGRATION EFFORT

SUMO-OWL has a high adequacy of knowledge extraction and a high adequacy of naming conventions

RELIABILITY

It does not compensate the integration effort

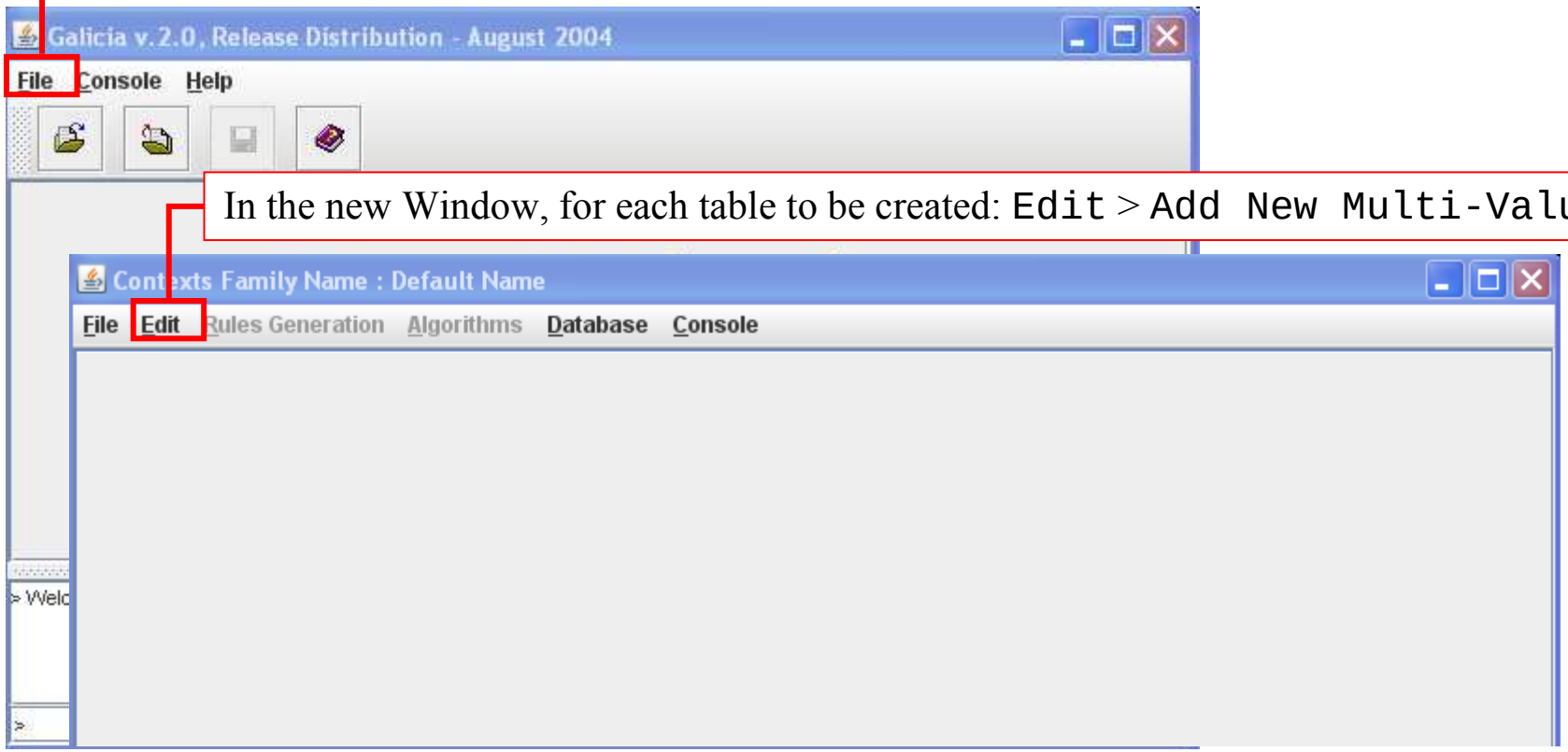
Obowebsite and OBO have a high purpose reliability, meanwhile SUMO-OWL and Dolce-Lite have a high theoretical support.

Based on Mariano Fernández-López, Asunción Gómez-Pérez and Mª Carmen Suárez Figuereoa's work

MULTI-FCA WITH GALICIA. HOW TO CREATE A SET OF TABLES

To download the tool: http://www.iro.umontreal.ca/~galicia/

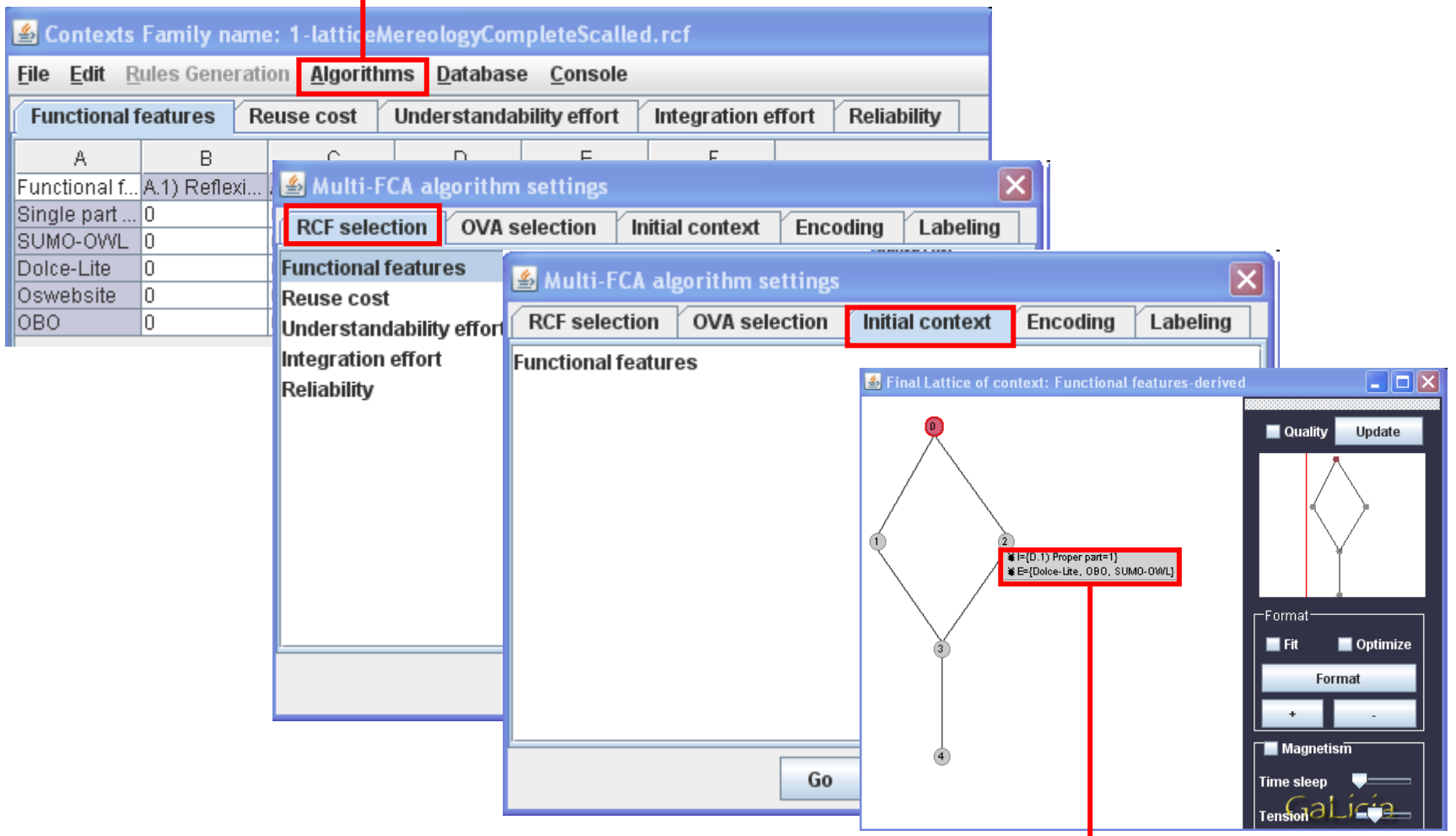
In the main window: `File` > `New Context or Family of Contexts`



In the new Window, for each table to be created: `Edit` > `Add New Multi-Valued Context`

MULTI-FCA WITH GALICIA. HOW TO GENERATE A LATTICE

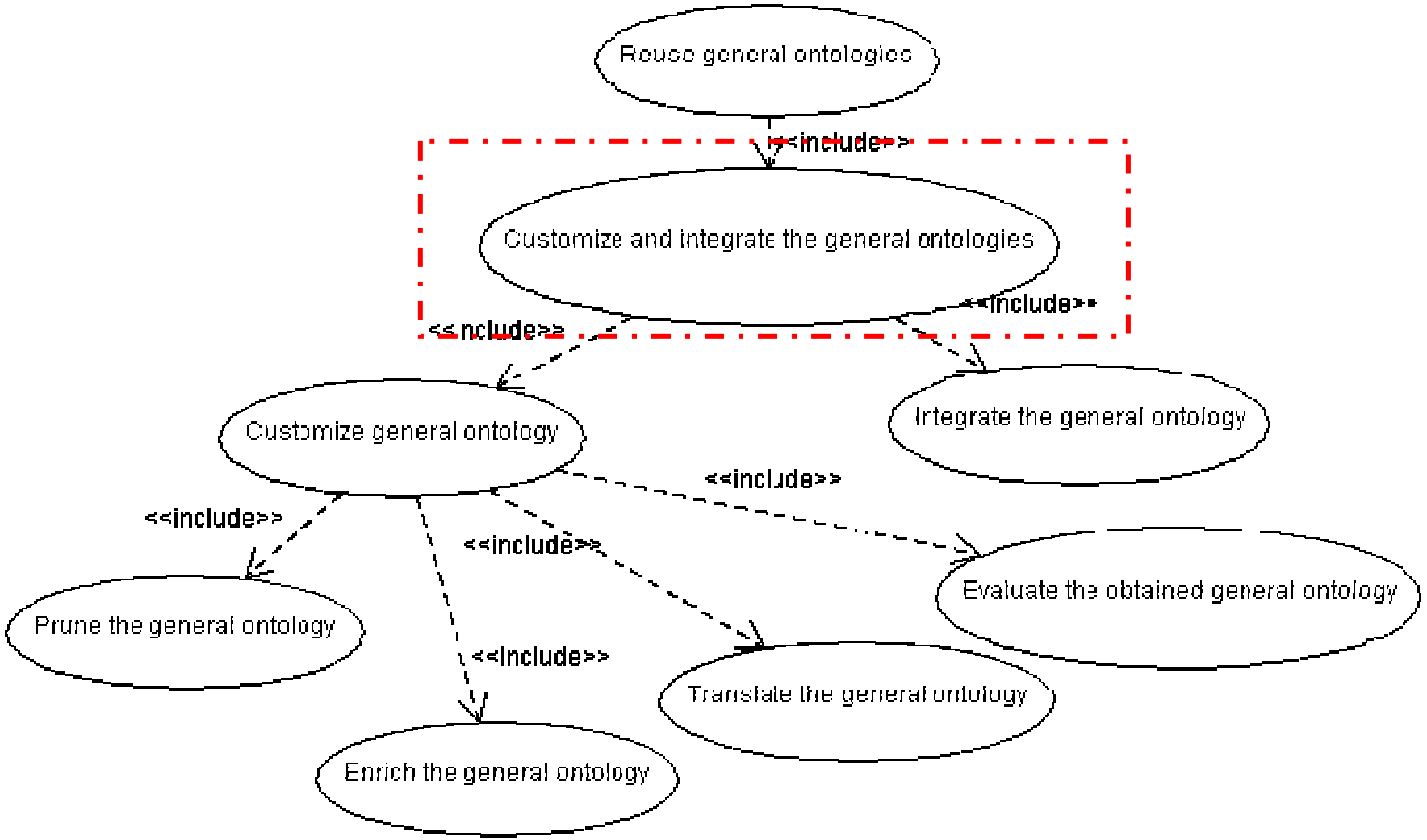
`Algorithms > Multi-FCA > Interactive Multi-FCA`



This information is obtained clicking the right button of the mouse

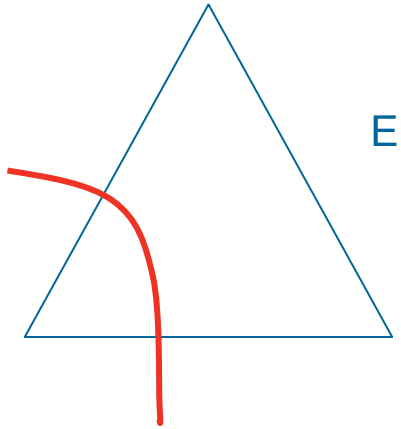
Based on Mariano Fernández-López, Asunción Gómez-Pérez and Mª Carmen Suárez Figuereoa's work

CUSTOMIZING AND INTETRATING THE GENERAL CANDIDATE ONTOLOGIES

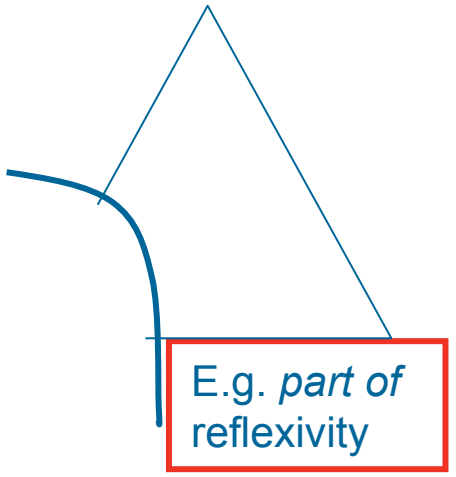


CUSTOMIZE THE SELECTED GENERAL ONTOLOGY

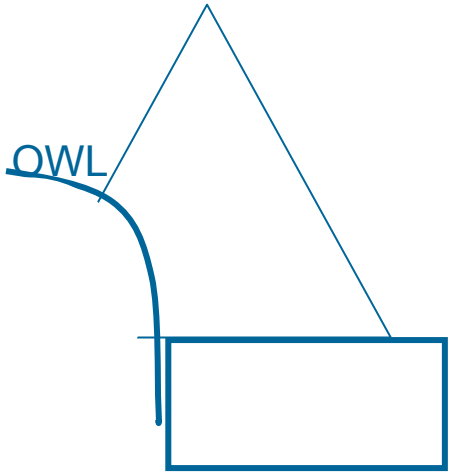
Pruning the MO (e.g. the relation *overlap* is not necessary in our domain ontology)



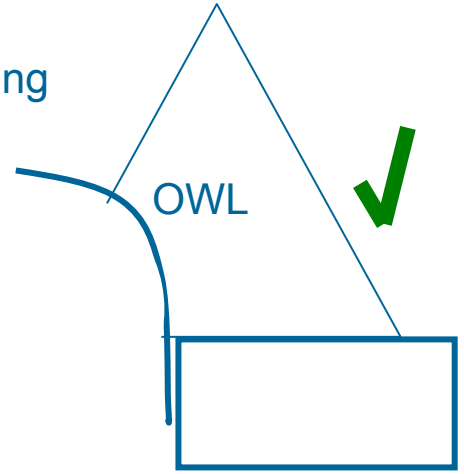
Enriching the MO



Translating into OWL



Evaluating



INTEGRATING THE ONTOLOGY TO BE REUSED

Links between terms of the reused ontology and the ontology to be developed should be established.

We have added the axioms identified in task 1.1 (e.g. *isMainActiveIngredient* is subrelation of *isPartOf*)

To answer CQ4 (*which substances does Frenadol® interact with?*) we have added this rule to the ontology:

```
interactsWith(?x, ?y), part(?x, ?z) -> interactsWith(?z, ?y)
```

CHECKING COMPETENCY QUESTIONS (I)

Informal CQ	Formal CQ	Example of answer

What drugs do have paracetamol?	# CQ1
	SELECT ?X
	WHERE
	{
	?X rdf:type ub:DrugSubstance .
	ub:Paracetamol ub:isProperPartOf ?X .
	}
		---------- 	
		|X |
		==========
		|FrenadolSubstance
		|BisolgripSubstance
		|CortafriolSubstance
		|DolgesicSubstance
		|TermalginSubstance
		|AlgidolSubstance
		|EfferalganSubstance
		|DolostopSubstance
		|GelocatilSubstance
		|ApiretalSubstance
		|PharmagripSubstance
		---------- 	

Which is the composition of Frenadol®?	# CQ2
	SELECT ?X
	WHERE
	{
	?X ub:isProperPartOf
	ub:FrenadolSubstance .
	}
		---------- 	
		|X |
		==========
		|Dextrometorphan
		|CitrateOfChlorpheniramine
		|Caffeine
		|Paracetamol
		---------- 	

CHECKING COMPETENCY QUESTIONS (II)

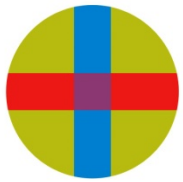
Informal CQ	Formal CQ	Example of answer

Which is the main active ingredient of Frenadol®?	# CQ3
	SELECT ?X
	WHERE
	{
	?X ub:isMainActiveIngredientOf
	ub:FrenadolSubstance .
	}
		---------- 	
		| X |
		==========
		| Paracetamol |
		---------- 	

Which substances do Frenadol® interacts with?	# CQ4
	SELECT ?X
	WHERE
	{
	ub:FrenadolSubstance ub:interactsWith
	?X .
	}
		---------- 	
		| X |
		==========
		| Rifanpicin |
		| Propranolol |
		| Isionazid |
		| EthylAlcohol |
		---------- 	

THE WORK TO DONE BY THE STUDENT

1. Presentation of general ontologies
2. The work to be done by the student (see the wording)



CEU
Universidad
San Pablo

GENERAL ONTOLOGIES

Course in Ontologies and the Semantic Web in the Master in Artificial Intelligence at UPM

Invited teacher: Mariano Fernández López

Presentation based on Mariano Fernández-López, Asunción Gómez-Pérez & Mari Carmen Suárez-Figueroa's work