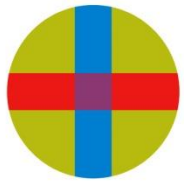


CEU
Universidad
San Pablo

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

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, Suárez-Figueroa MC (2013) *Methodological guidelines for reusing general ontologies.* Data & Knowledge Engineering 86:242-275

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

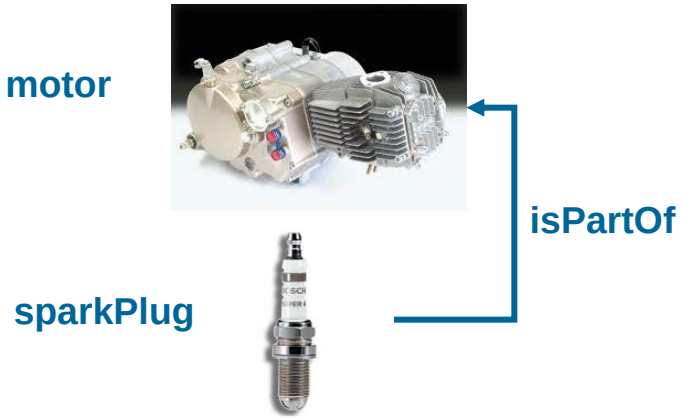
van Heijst G, Schreiber ATh, Wielinga BJ (1997) *Using explicit ontologies in KBS development*. International Journal of Human-Computer Studies 45:183–292

A CASE OF GENERAL ONTOLOGIES: MEREOLOGIES

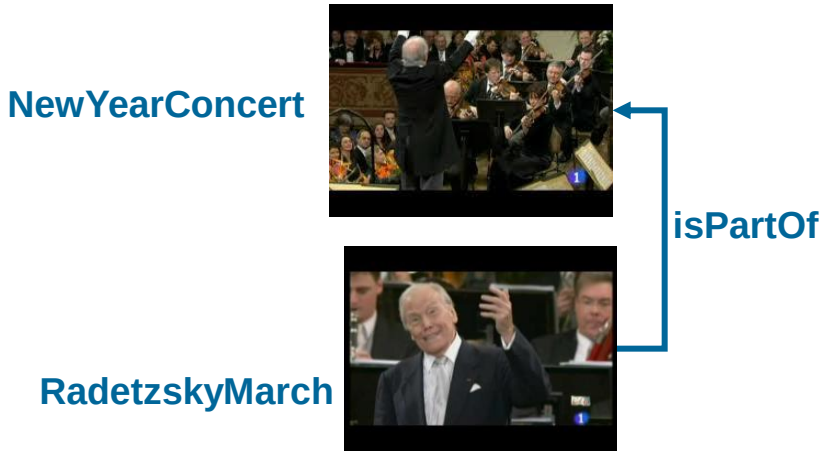
A mereology is a formal theory that axiomatizes the relation *isPartOf*.

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



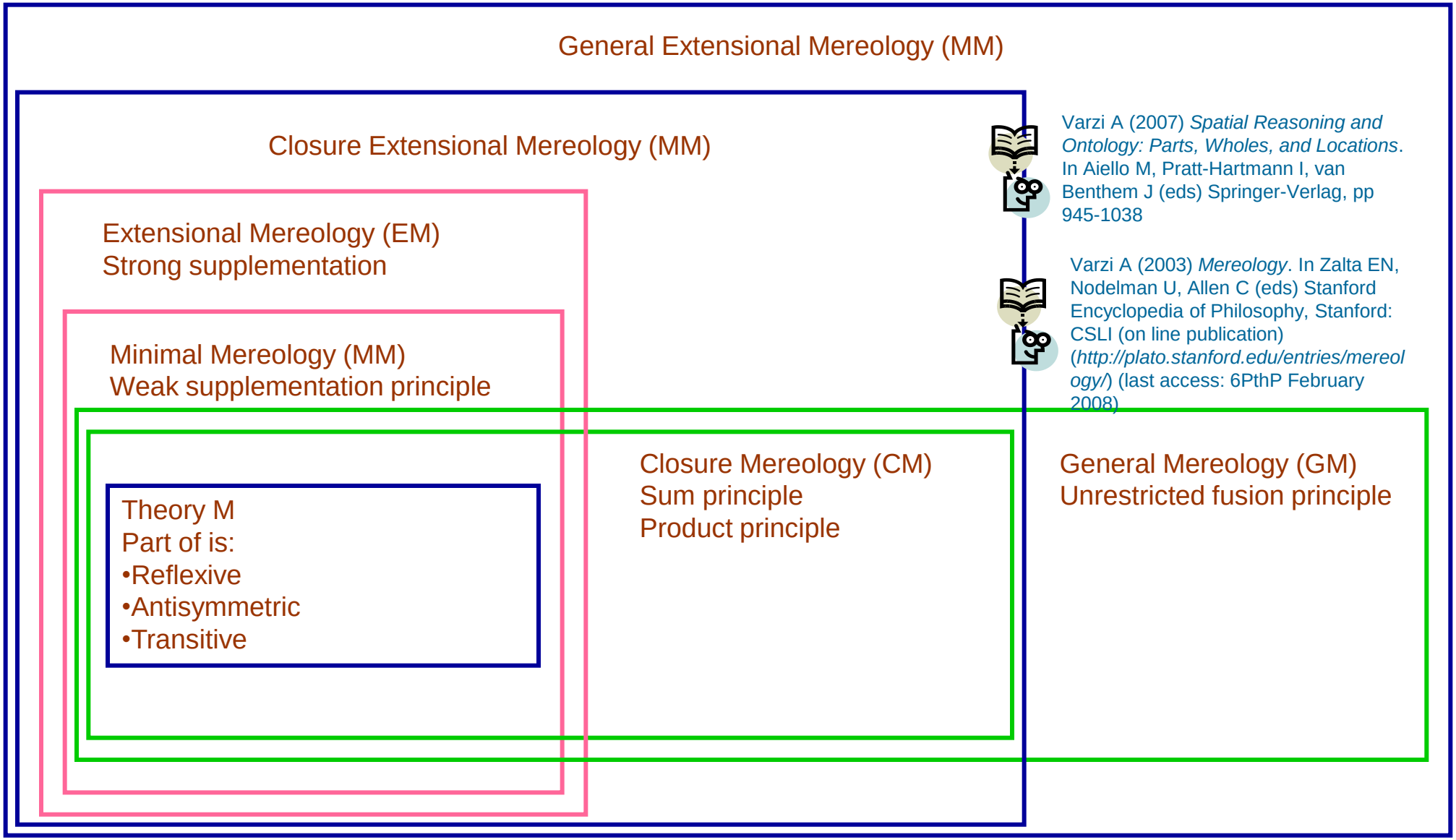
http://i.ytimg.com/vi/u6cbhlto9sA/hqdefault.jpg
http://i.ytimg.com/vi/6o7dmM3YNN8/hqdefault.jpg

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

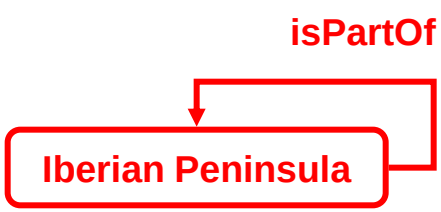
Minimal Mereology (MM)
Weak supplementation principle

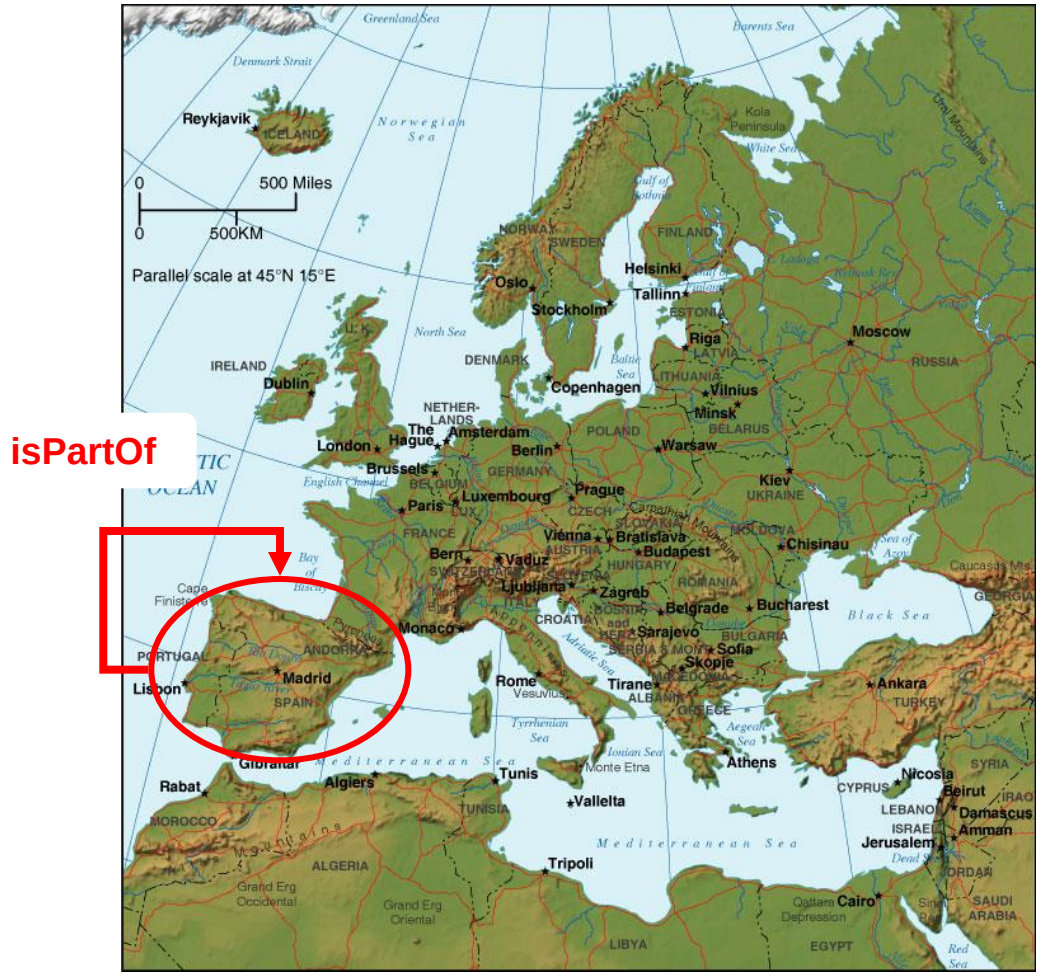
Theory M
Part of is:
- Reflexive
- Antisymmetric
- Transitive

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

MINIMAL MEREOLOGY. REFLEXIVITY

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

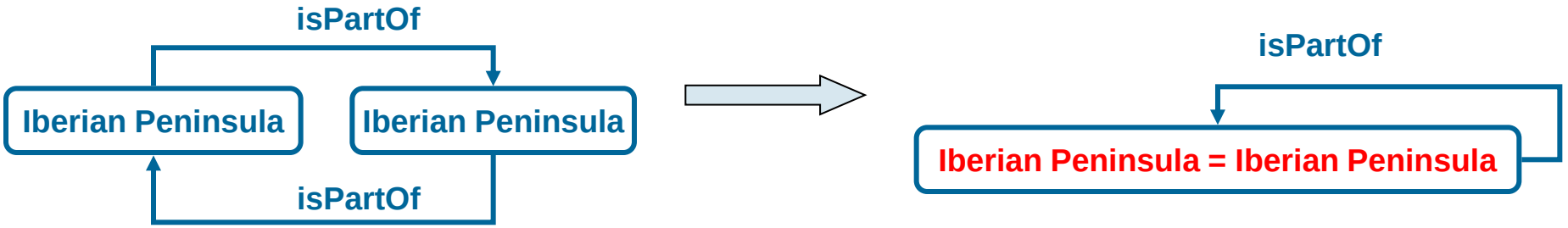




http://www.map-of-europe.us/europe-relief-map.jpg

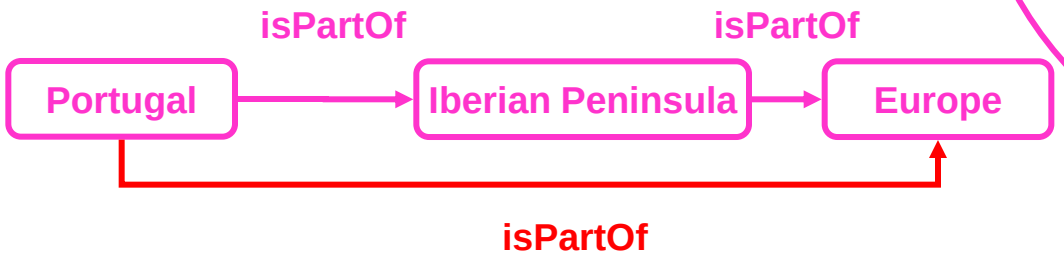
MINIMAL MEREOLOGY. ANTISYMMETRY

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.



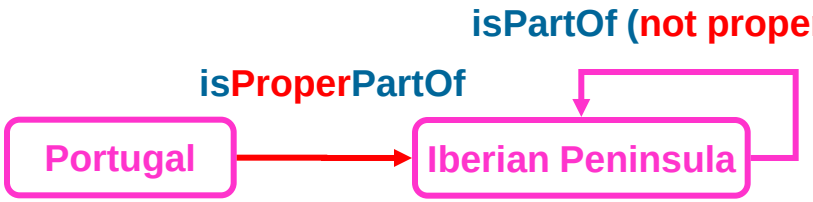
MINIMAL MEREOLOGY. TRANSITIVITY

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



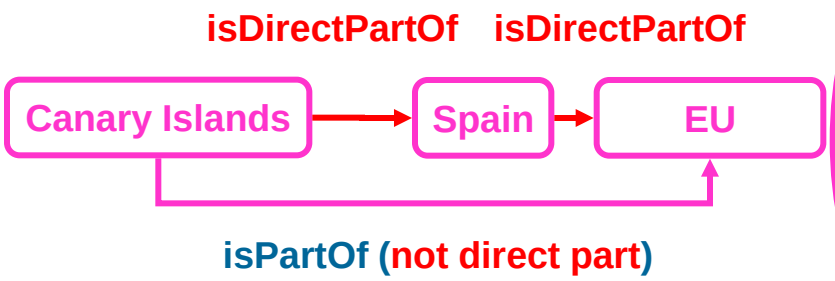
MINIMAL MEREOLOGY. PROPER PART

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



MINIMAL MEREOLOGY. DIRECT PART

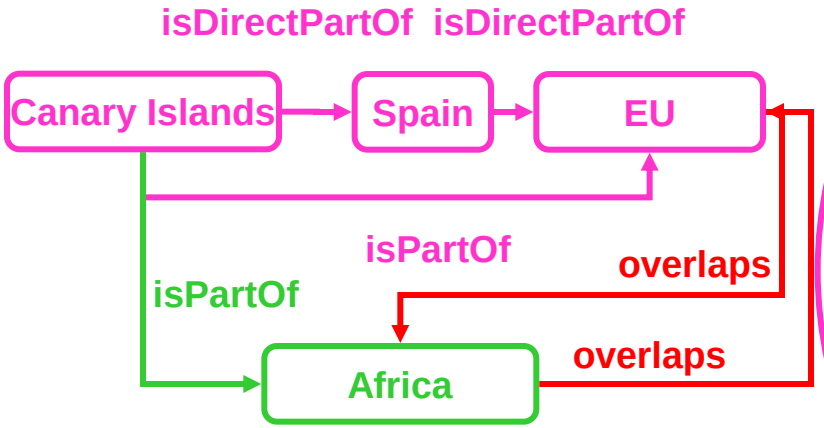
X is **direct part** of *y* if and only if *x* is proper part of *y* and there is no part between *x* and *y*.



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

MINIMAL MEREOLOGY. OVERLAPS

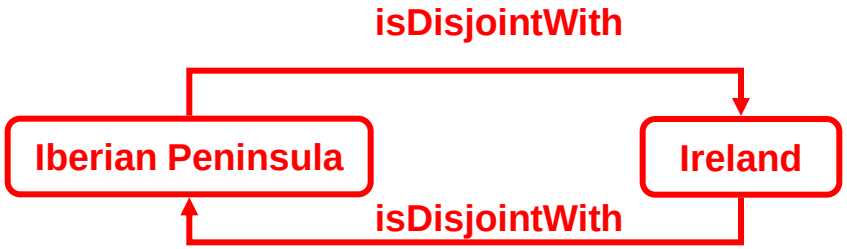
The relation **overlaps** is defined as a sharing part. That is, *x* and y overlap if and only if there is a *z* such us *z* is part of *x* and part of *y*.



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

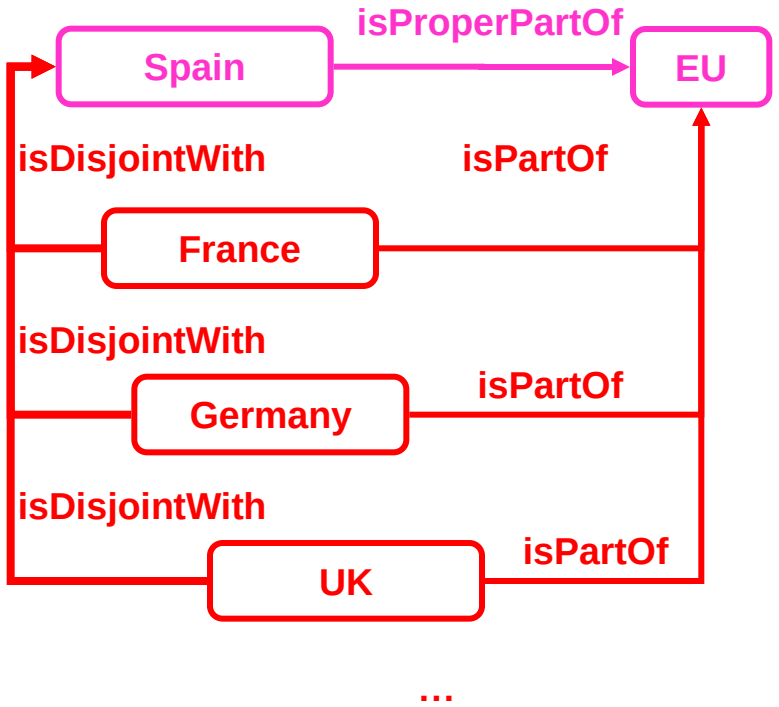
MINIMAL MEREOLOGY. IS DISJOINT WITH

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

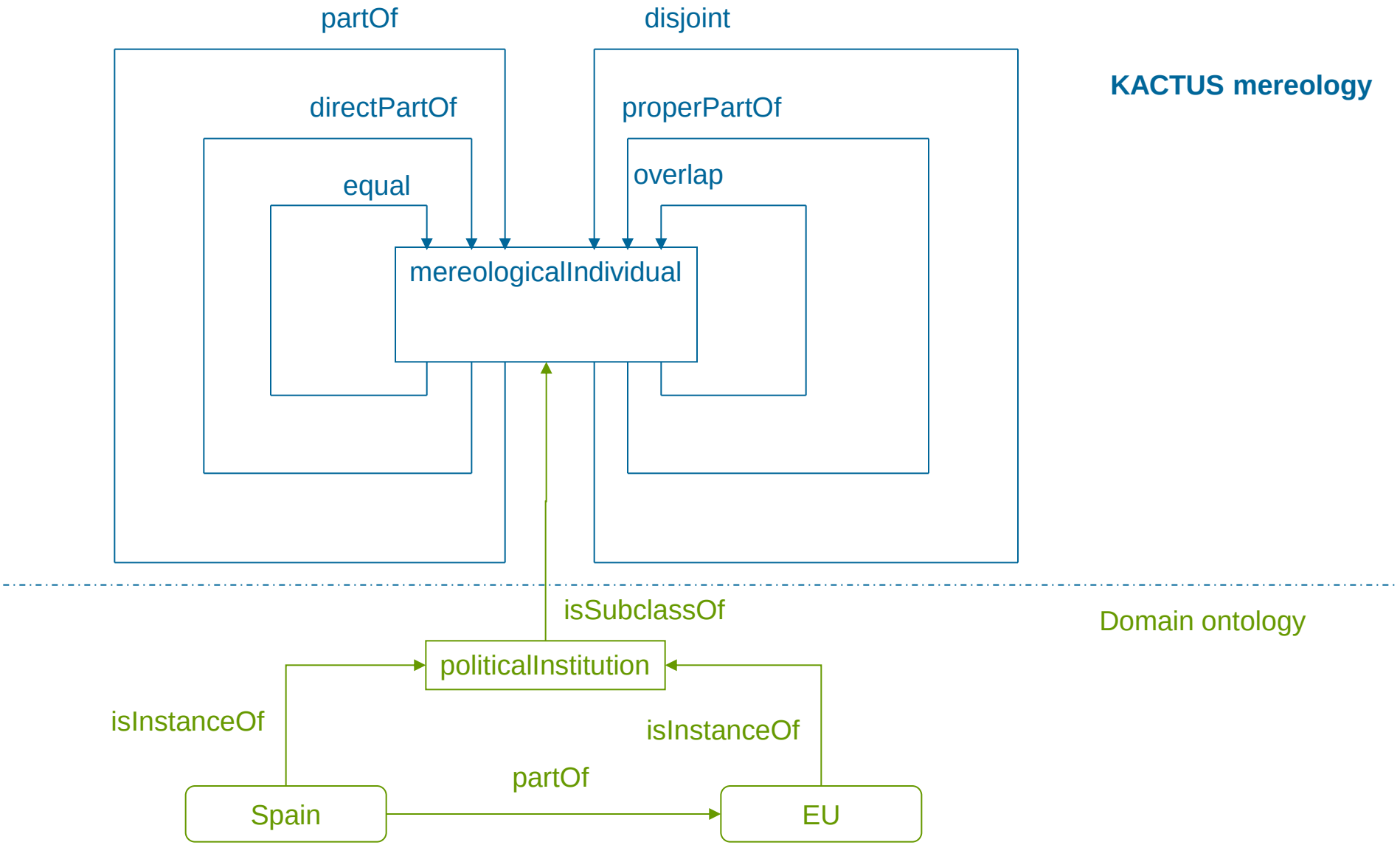


MINIMAL MEREOLOGY (VII)

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

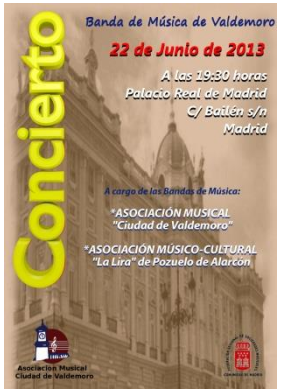
3. Some important types of general ontologies
   a. Mereologies
   b. Time ontologies

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



Granularity of days: the Valdemoro Music Band concert at Palacio Real was celebrated the 22nd of June of 2013

Granularity of minutes: the Valdemoro Music Band concert was celebrated the 22nd of June of 2013 at 19:30

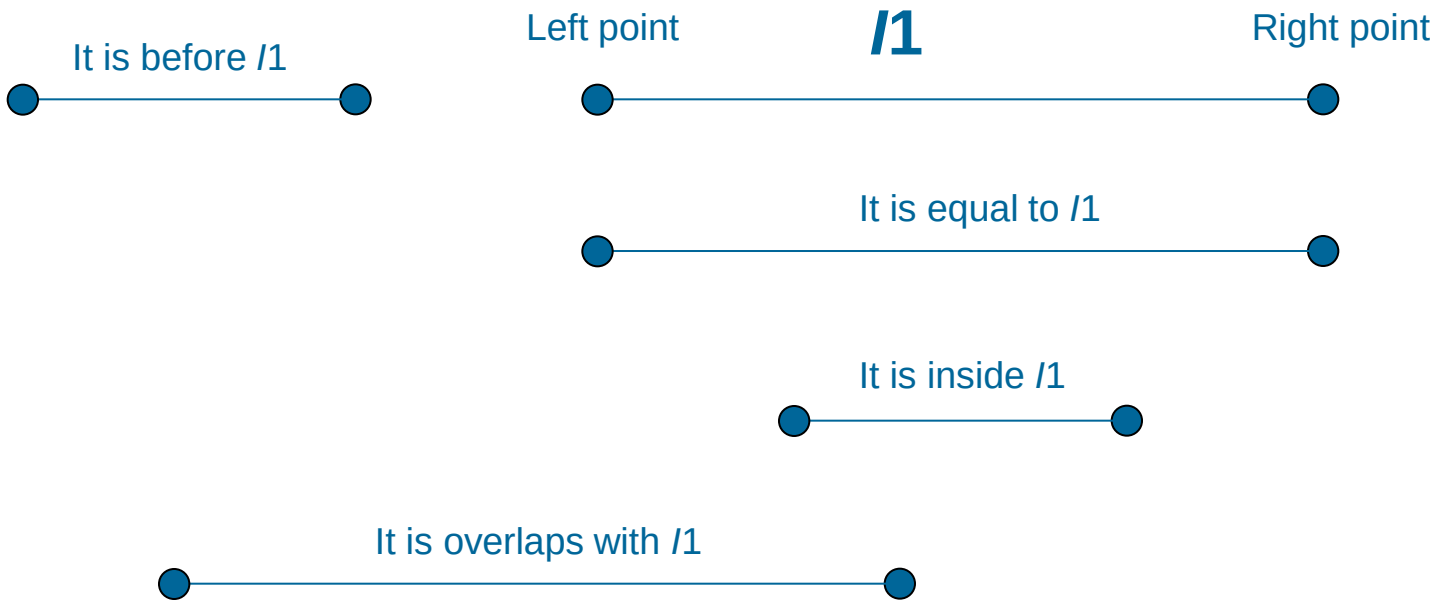
Time interval. Also as a first intuitive approximation, we can see a time interval as the time between two time points.

Left point — Right point

Example: Johan Sebastian Bach's life

31st of March of 1685 — 28th of July of 1750

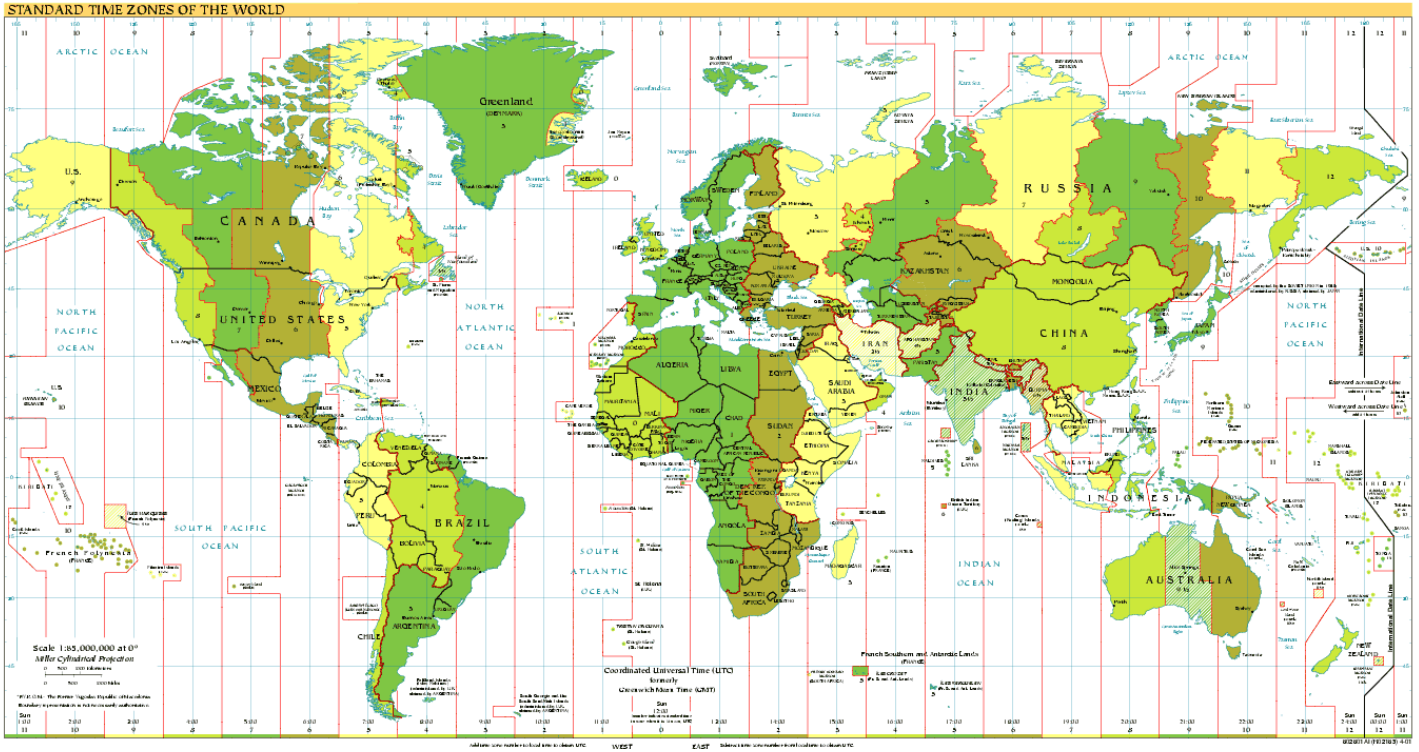
TIME INTERVAL ALGEBRA



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

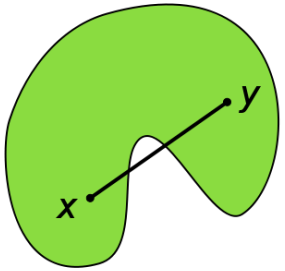


The axiomatization of time zones is complex. Thus, for example, the Northern and Southern hemispheres perform Daylight/Summer Time adjustments during opposing times during the year (corresponding to seasonal differences in the two hemispheres)

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)

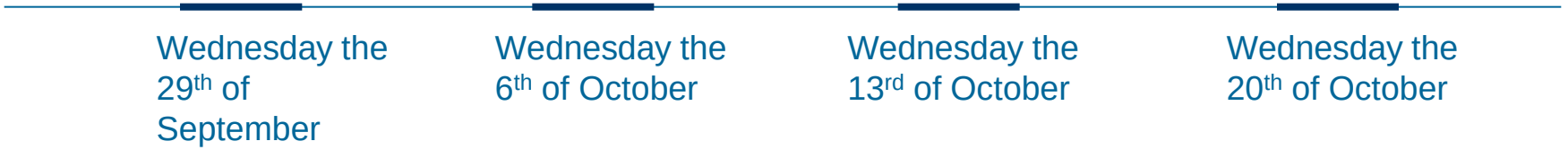
Non convex intervals. This notion is borrowed from geometry:



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”).

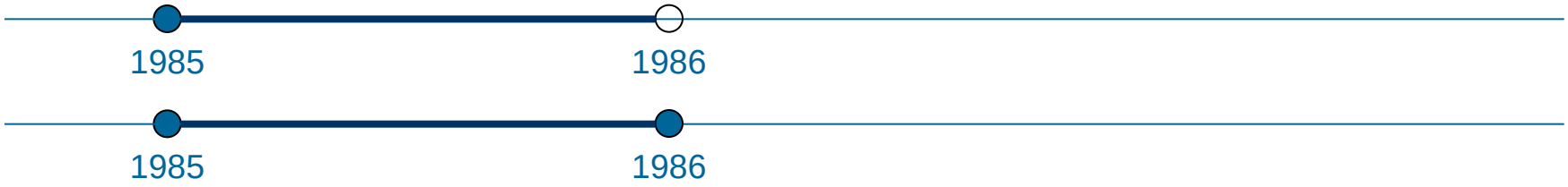


TIME MODELING. OPTIONAL EXTENSIONS (II)

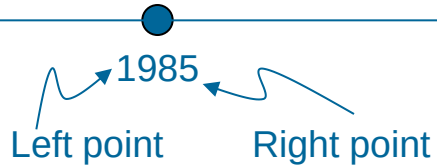
Open intervals. Sometimes, the interval end points might be or not included in the interval. For example, [1985, 1986) is an interval left closed and right open.

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



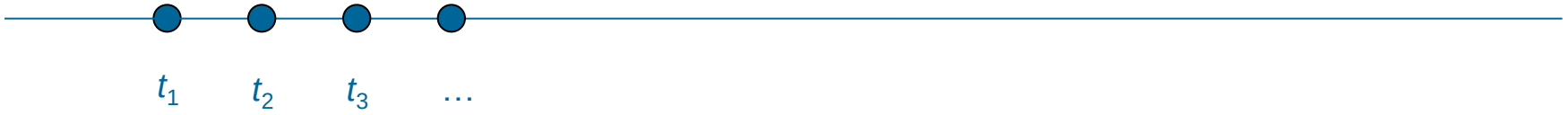
Examples of **non** proper interval



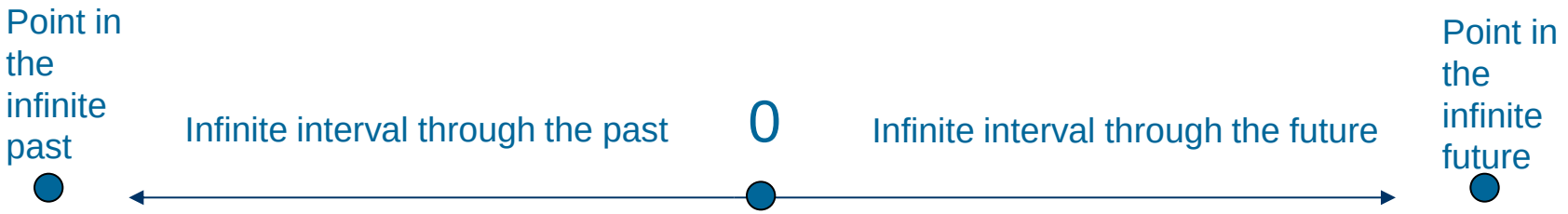
TIME MODELING NOTIONS. OPTIONAL EXTENSIONS (III)

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

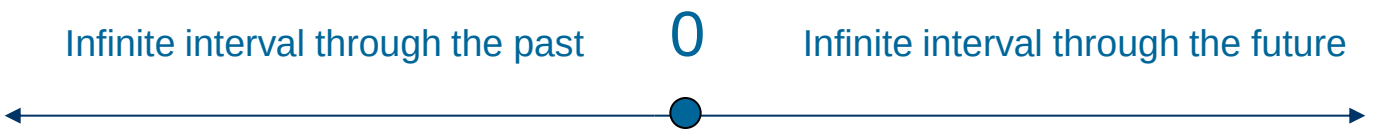
This feature eliminates models of time with branching futures and other conflations of time and possibility or limited knowledge.



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



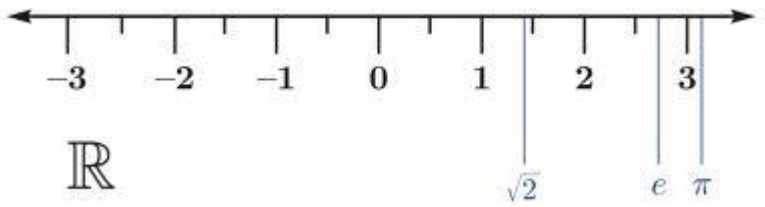
b) Infinite pass: intervals without left point. Infinite future: intervals without right point

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.



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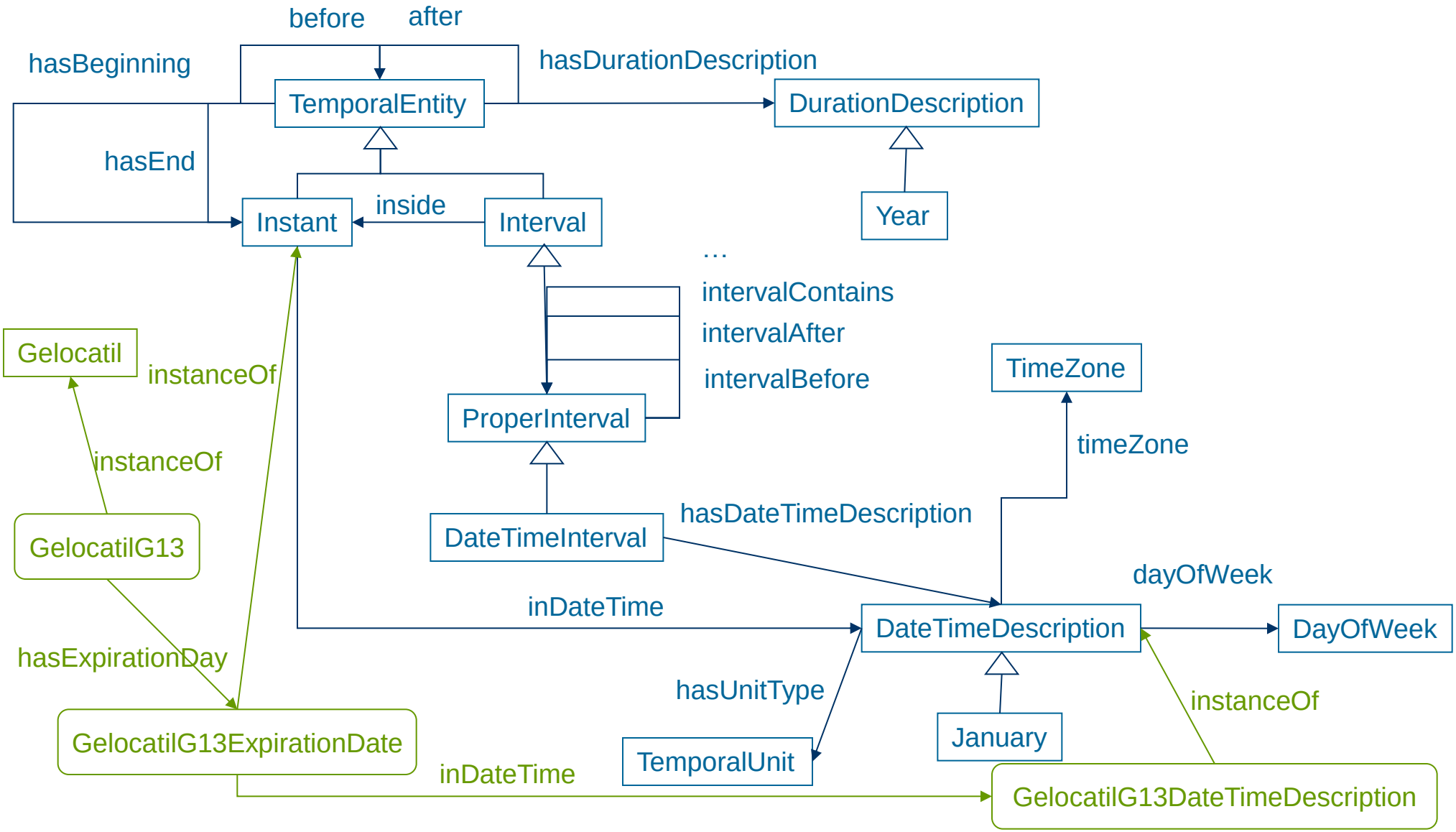
TIME OWL: EXAMPLE OF GENERAL ONTOLOGY



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:

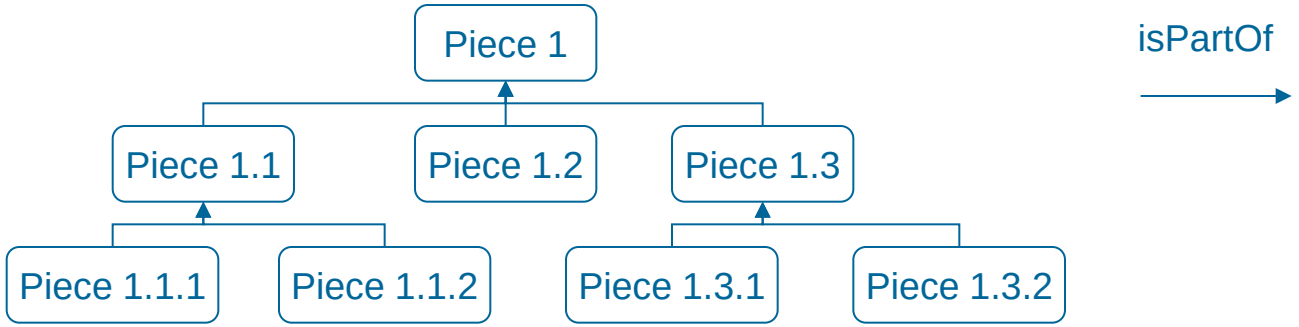
```
# SPARQL query SQ1
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX ub: <http://www.NewOnto1.org/killer201004271447#>
SELECT ?X
WHERE
{
        ?X rdf:type ub:drug .
        ub:iron ub:isPartOf ?X .
}
```

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

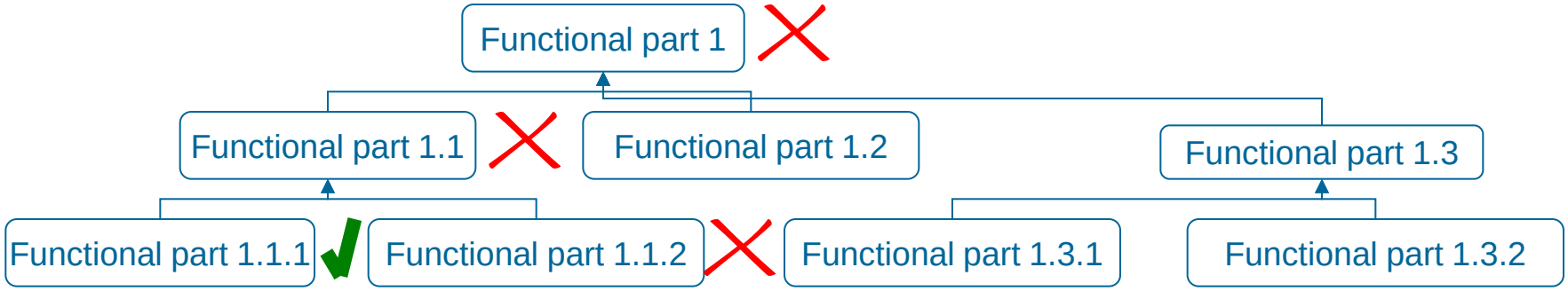
A parts inventory for the devices made in a factory in which we want to be able to find the "explosion" of parts required (i.e. for each part we can see the sub-parts).



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

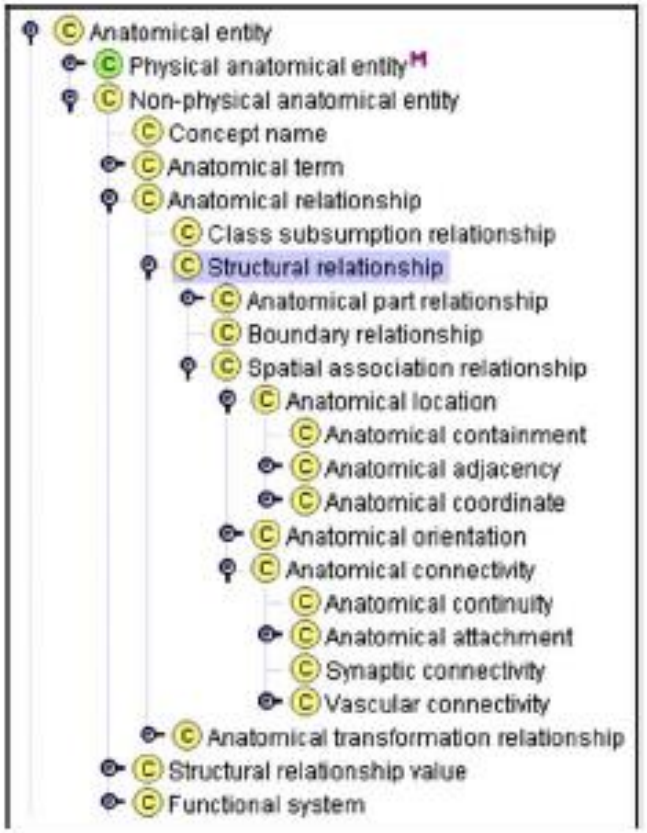
A fault finding system for a device in which we want to progressively narrow down the functional region of the fault.



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

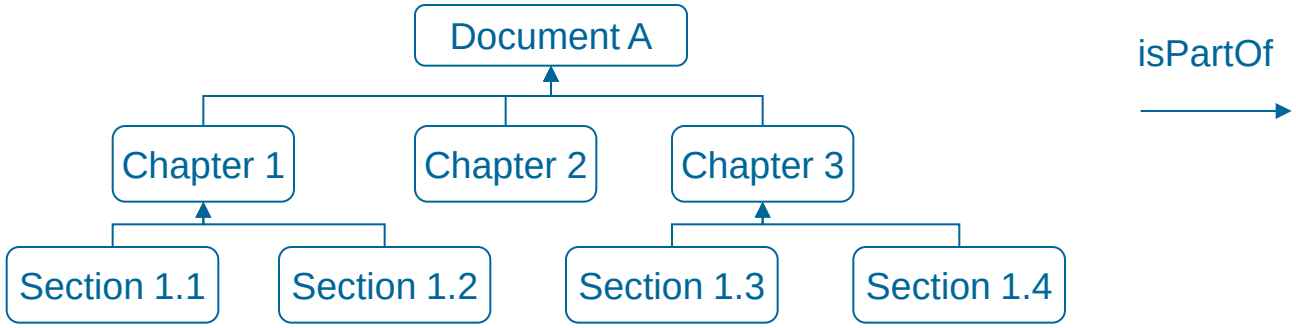
An anatomy representation such as the Digital Anatomist Foundational Model of Anatomy (*http://www.bioontology.org/*)



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: 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.

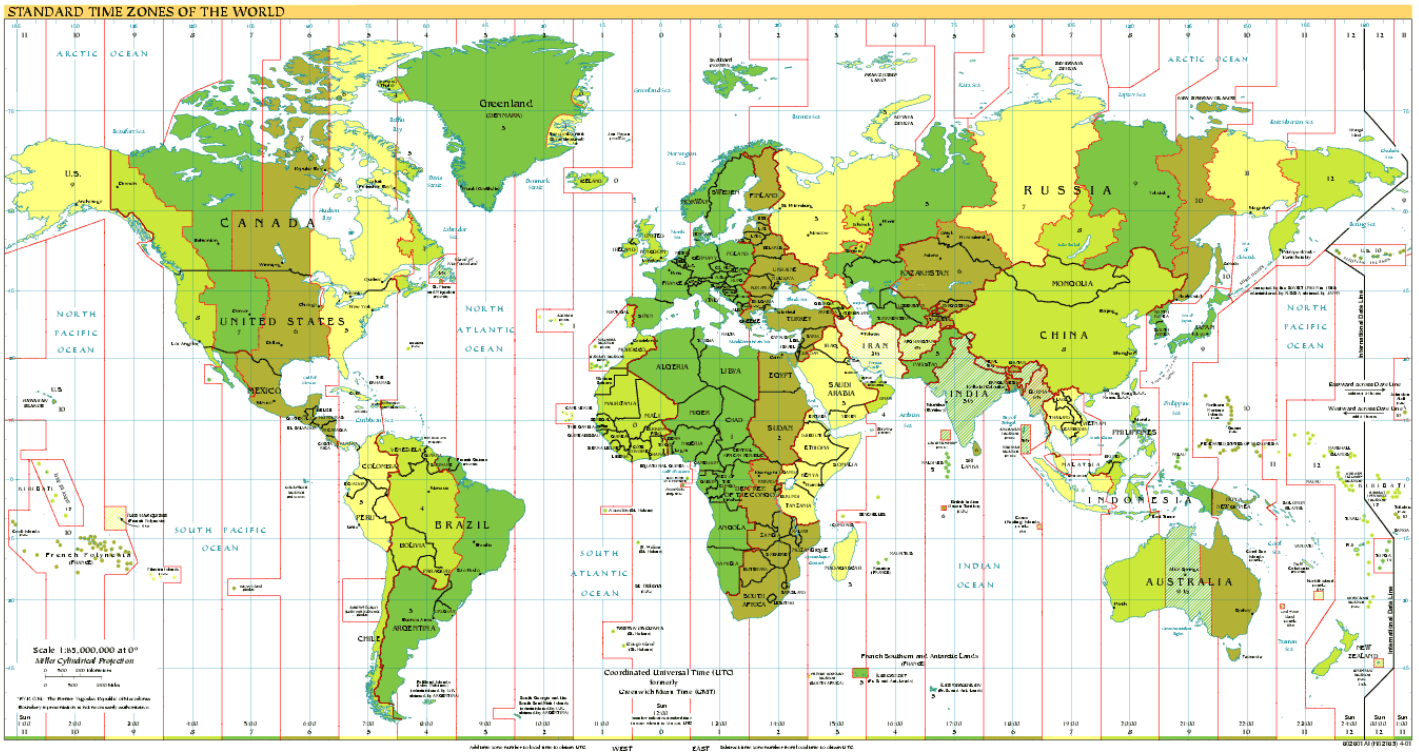
http://www.memory-srl.com.ar/img/como/3.jpg

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/*

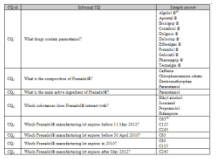
HOW TO REUSE GENERAL ONTOLOGIES

1. Bibliography

2. The notion of general ontology

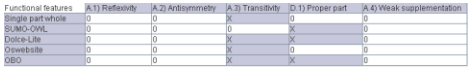
3. The reuse of general ontologies
   a. Why to reuse them?
   b. How to reuse them?
   c. Conclusions

4. The work to be done by the student?

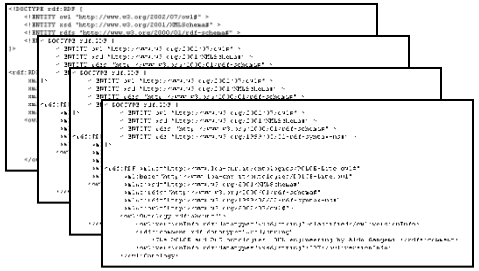


ORSD

1. Conduct a comparative study of reusable general ontologies

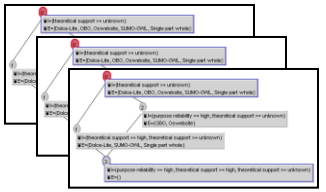


Formal concept representing the comparative study



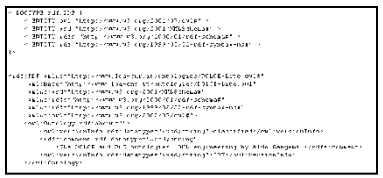
General ontologies

2. Make a decision on which general ontology to reuse

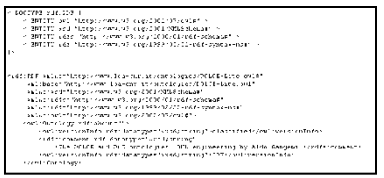


Lattices to determine the most appropriate ontology

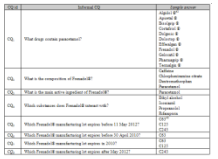
3. Assemble the whole ontology



Assembled whole ontology



Choosen a general ontology

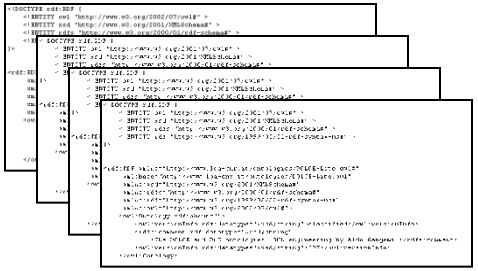


ORSD

1. Conduct a comparative study of reusable general ontologies

Functional features	A.1) Reflexivity	A.2) Antisymmetry	A.3) Transitivity	D.1) Proper part	A.4) Weak supplementation
Single part whole	0	0	X	0	0
SUMO-OWL	0	0	0	X	0
Dolce-Lite	0	0	0	X	0
Oswebsite	0	0	X	0	0
OBO	0	0	X	X	0

Formal concept representing the comparative study



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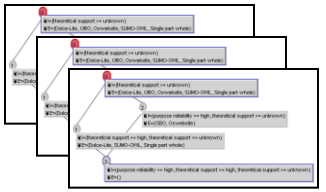

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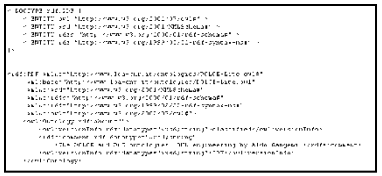
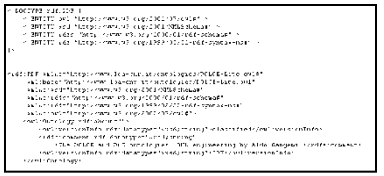
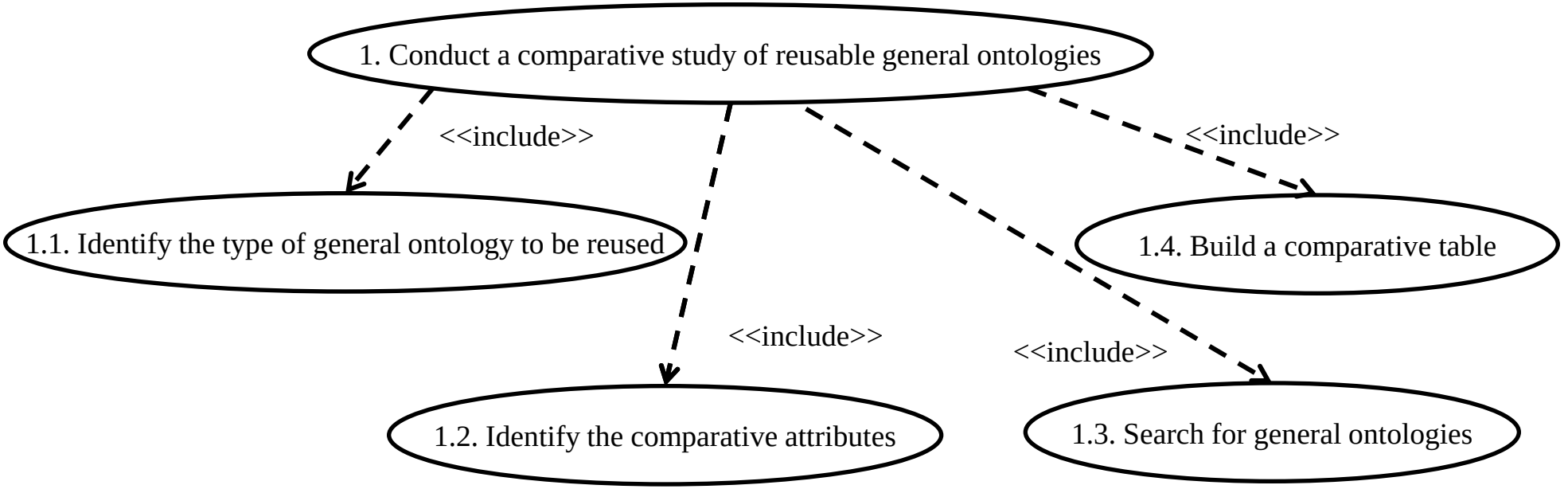


Assembled whole ontology



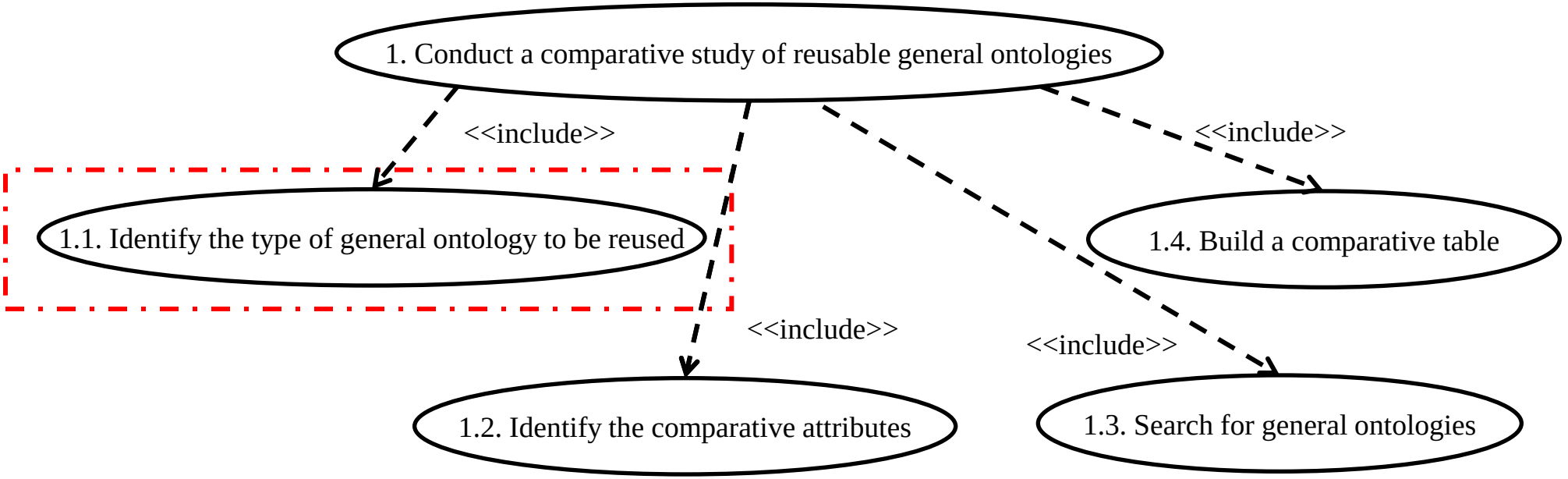
Choosen a general ontology

CONDUCT A COMPARATIVE STUDY OF REUSABLE GENERAL ONTOLOGIES



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

IDENTIFY THE TYPE OF GENERAL ONTOLOGY TO BE REUSED



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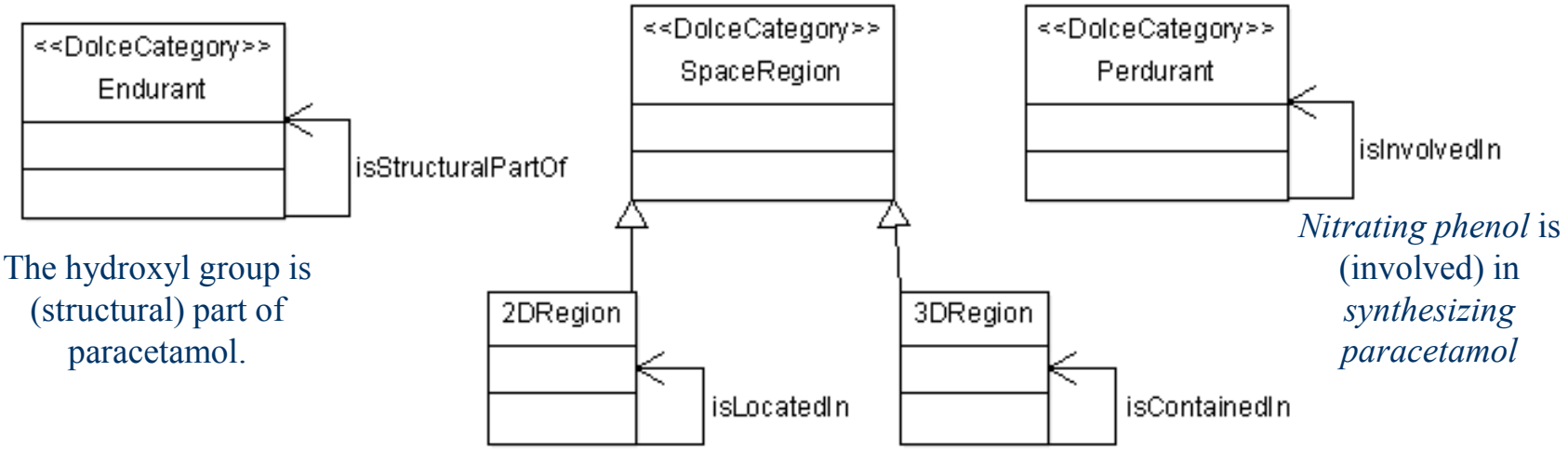
HEURISTIC 1. MEREOLOGY REUSE I

Heuristic 1 (mereology reuse I). We should *reuse an implemented mereology* if 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.



The hydroxyl group is (structural) part of paracetamol.

Sant Cugat del Vallès (the location of *Pharmacia Iberia ® headquarters*) is (located) in *the province of Barcelona*

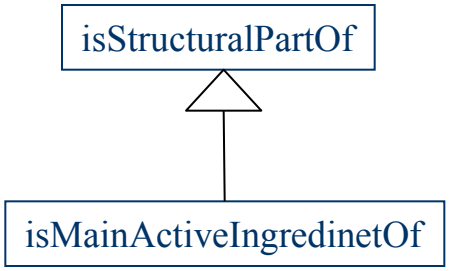
A *small bottle* is (contained) in its *box*.

Nitrating phenol is (involved) in *synthesizing paracetamol*

C. Keet, A. Artale, Representing and reasoning over a taxonomy of part–whole relations, Applied Ontology 3 (2008) 91–110.

HEURISTIC 2. MEREOLOGY REUSE II

Heuristic 2 (mereology reuse II). If the CQ refers to a relation *S* that is a subrelation of an *R* that meets conditions CM_1 and CM_2, then an implemented mereology should be reused.



HEURISTIC 3. TIME MODELING REUSE

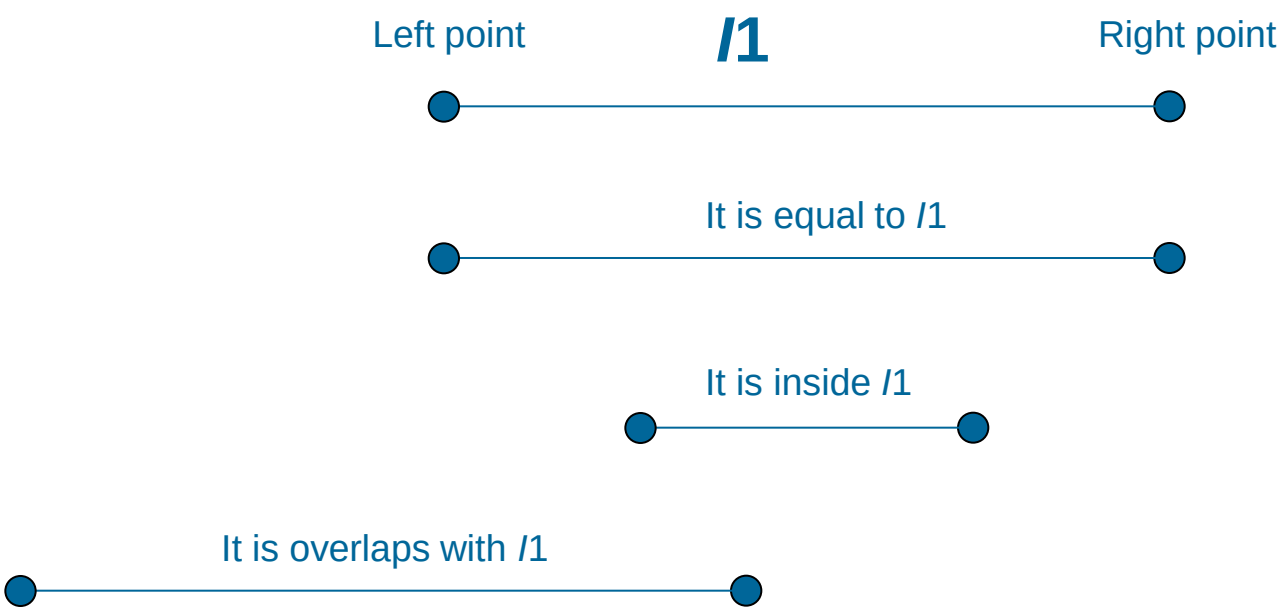
Heuristic 3 (time modelling reuse). We should *reuse a time ontology* if some of the following words appear in the CQ:

- Nouns: ‘day’, ‘minute’, ‘weekend’, ‘midnight’, ‘millennium’, ‘era’, ‘semester’, ‘summer’, [the] ‘future’, [the] ‘past’, ‘month’.
- Proper names: ‘Monday’, ‘January’, ‘New Year’s Eve’, ‘Washington’s Birthday’.
- Specialized time patterns: 8.00, 12/2/00, 1994, 1960s.
- Adverb: ‘currently’, ‘hourly’, ‘daily’, ‘monthly’.
- Noun/adverb of time: ‘today’, ‘yesterday’, ‘now’.
- Prepositions of time: ‘on’, ‘in’, ‘at’, ‘from’, ‘to’, ‘before’, ‘after’, ‘during’.
- Conjunctions of time: ‘before’, ‘after’, ‘while’, ‘when’.

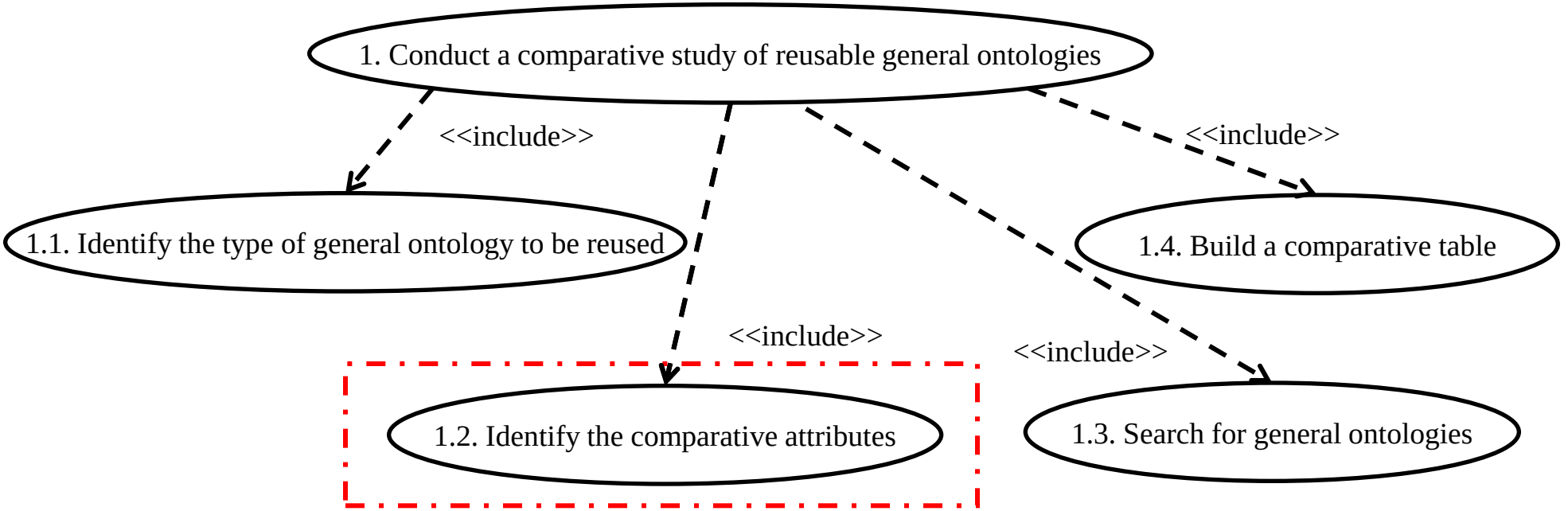
L. Ferro, Instruction manual for the annotation of temporal expressions, Tech. rep., The MITRE Corporation (2001). ftp://jaguar.ncsl.nist.gov/ace/phase2/docs/mtrinstructionmanual_v1_32.pdf

HEURISTIC 4. MEREOLOGY III

Heuristic 4 (mereology reuse III). If the CQ refers to a time relation (using the words ‘in’, ‘during’, etc.), then an implemented mereology should be reused.



IDENTIFY THE COMPARATIVE ATTRIBUTES



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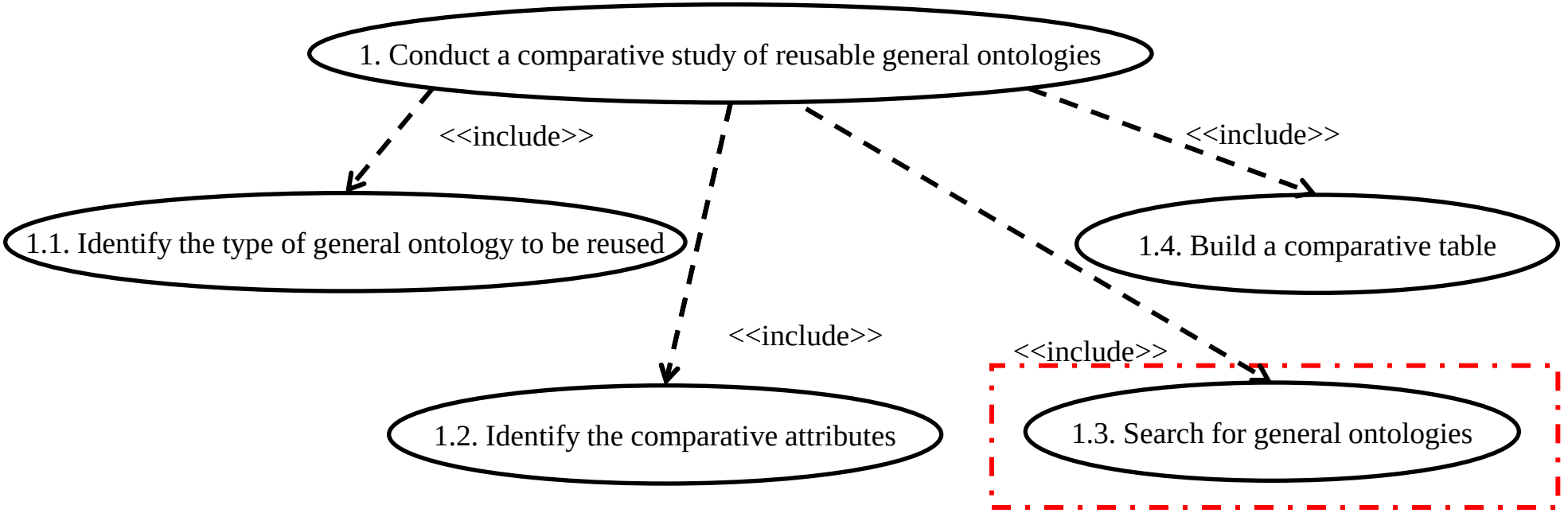
SEARCH FOR GENERAL ONTOLOGIES



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SEARCHING FOR ONTOLOGIES

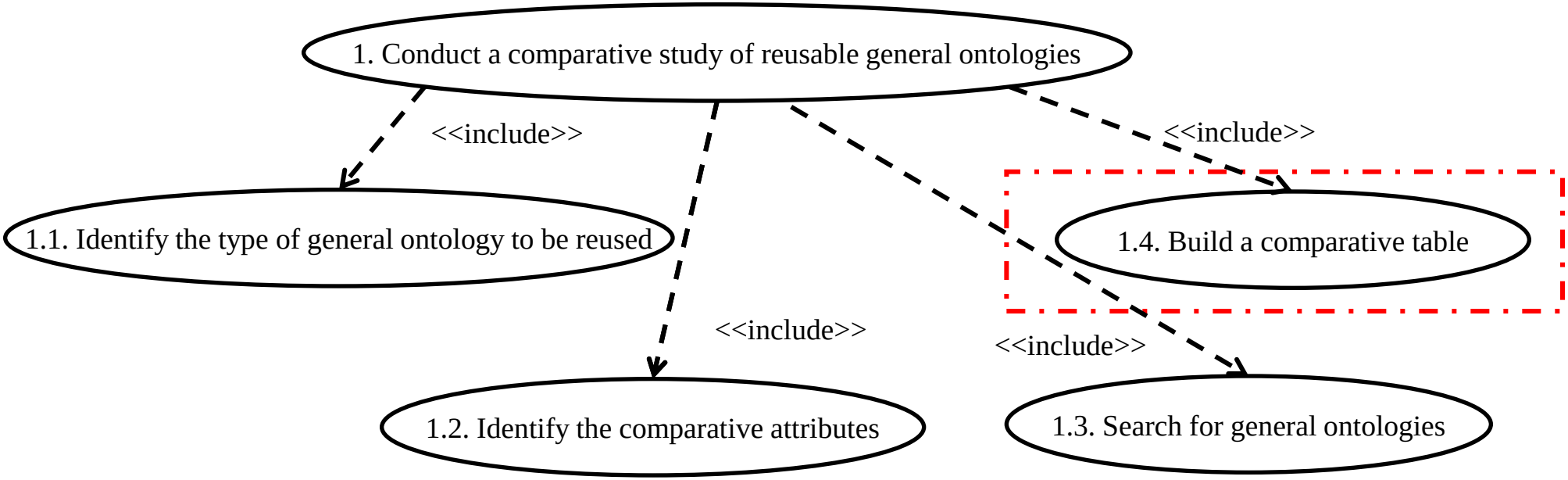
We can use:

- **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.).

Identified ontologies	Project or institution	General theory
Single part whole	W3C	Mereology
SUMO-OWL	IEEE Standard Upper Ontology working group	Mereology Time
DOLCE-Lite	Italian Research Council (CNR)	Mereology Time
Oswebsite	OS Open data	Mereology
OBO	Open Biological and Biomedical Ontologies	Mereology
OWL-Time	W3C	Time
AKT-Time	Advanced Knowledge Technologies (AKT)	Time

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

BUILD A COMPARATIVE TABLE



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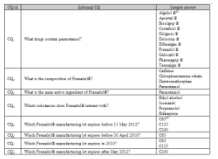
Single part whole	0	0	X	0	0
SUMO-OWL	0	0	0	X	0
Dolce-Lite	0	0	X	X	0
Oswebsite	0	0	X	0	0
OBO	0	0	X	X	0

Functional features	Time points	Time intervals	Absolute time	Relations between temporal entities	Modeling of conv...	Modeling of...
OWL-Time	X	X	X	X	X	0
SUMO-OWL	X	X	0	X	0	0
AKT-Time	X	X	X	0	X	0



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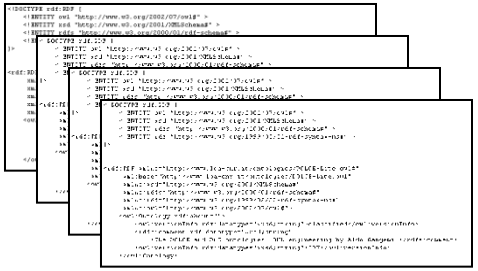

General ontologies

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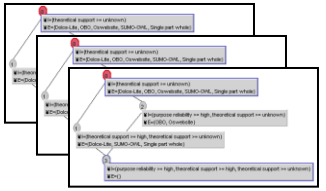

Lattices to determine the most appropriate ontology

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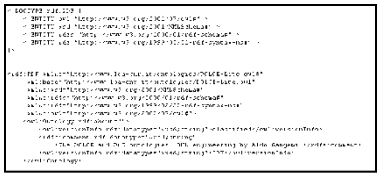

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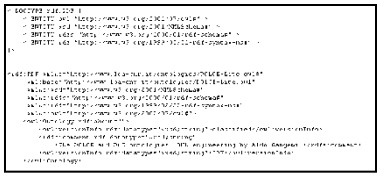
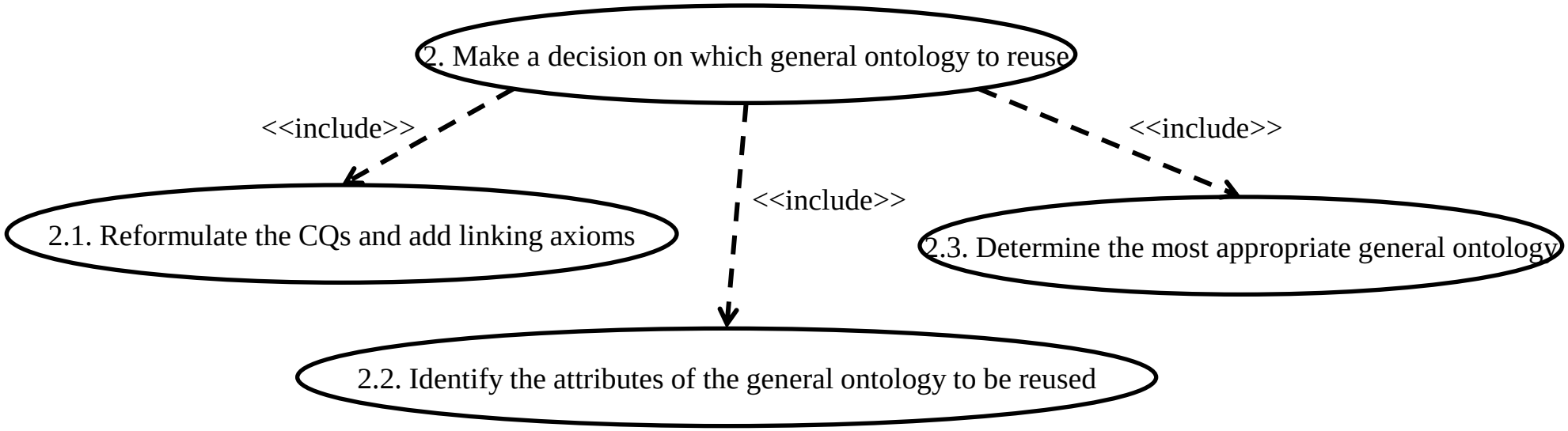
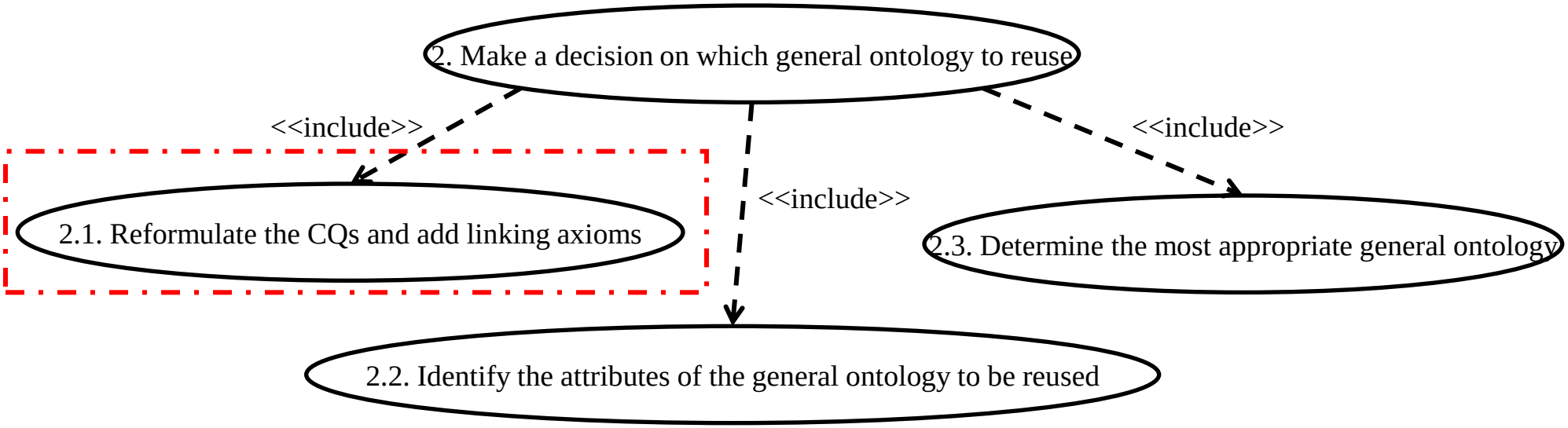


Choosen a general ontology

MAKE A DECISION ON WHICH GENERAL ONTOLOGY TO REUSE



REFORMULATE THE CQs AND ADD LINKING AXIOMS



REFORMULATE THE CQs AND ADD LINKING AXIOMS

Heuristic 5 (overlap). If we want to know if two objects have common parts, then we should reformulate the CQ to include the term *overlap*.

Heuristic 6 (underlap). If we want to know if two objects have common wholes, then we should reformulate the CQ to include the term *underlap*.

Heuristic 7 (proper part). If we want to know the parts of an object not including the object itself, then we should reformulate the CQ to include the term *proper part of*.

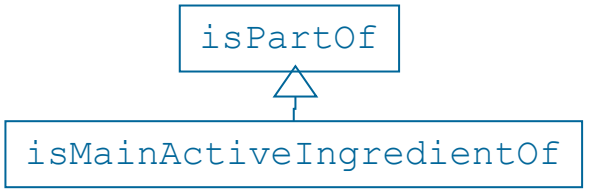
Heuristic 8 (direct part). If we want to know the first level of decomposition of an object, then we should reformulate the CQ to include the term *is direct part of*

Heuristic 9 (part of). If we want to know the parts of an object, including the object itself, then we should reformulate the CQ to include the term *is part of*. A typical case is that in which the mereological relation appears in a composition of relations.

Heuristic 10 (disjoint). If we want to know which parts of object o_1 are not in object o_2, then we should reformulate the CQ to include the term *are disjoint*.

Heuristic 11 (subrelations of *part_of*). If we applied Heuristic 2, then we should introduce a linking axiom establishing that *S* is a subrelation of *part_of*.

EXAMPLES

Do *Histidine metabolism* and *Biosynthesis of secondary metabolites* have reactions in common?	⇒	Do *Histidine metabolism* and *Biosynthesis of secondary metabolites* **overlap**?
Do R03457 and R03012 reactions belong to common pathways?	⇒	Do R03457 and R03012 reactions **underlap**?
What is the composition of paracetamol?	⇒	Which are the **proper parts** of paracetamol?
Which are the reactions of *Histidine metabolism*?	⇒	Which are the **direct parts** of the *Histidine metabolism*?
Are Pharmacia Iberia ® headquarters located in Spain?	⇒	Are Pharmacia Iberia ® headquarters located in some **part** of Spain?
Which reactions of *Histidine metabolism* do not belong to *Biosynthesis of secondary metabolites*?	⇒	Which reactions of *Histidine metabolism* are **disjoint** with *Biosynthesis of secondary metabolites*?
Which is the main active ingredient of Apiretal®?	⇒	

EXAMPLE OF UNDERLAP

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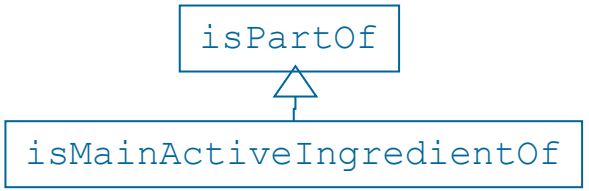
Which is the main active ingredient of Apiretal®?	

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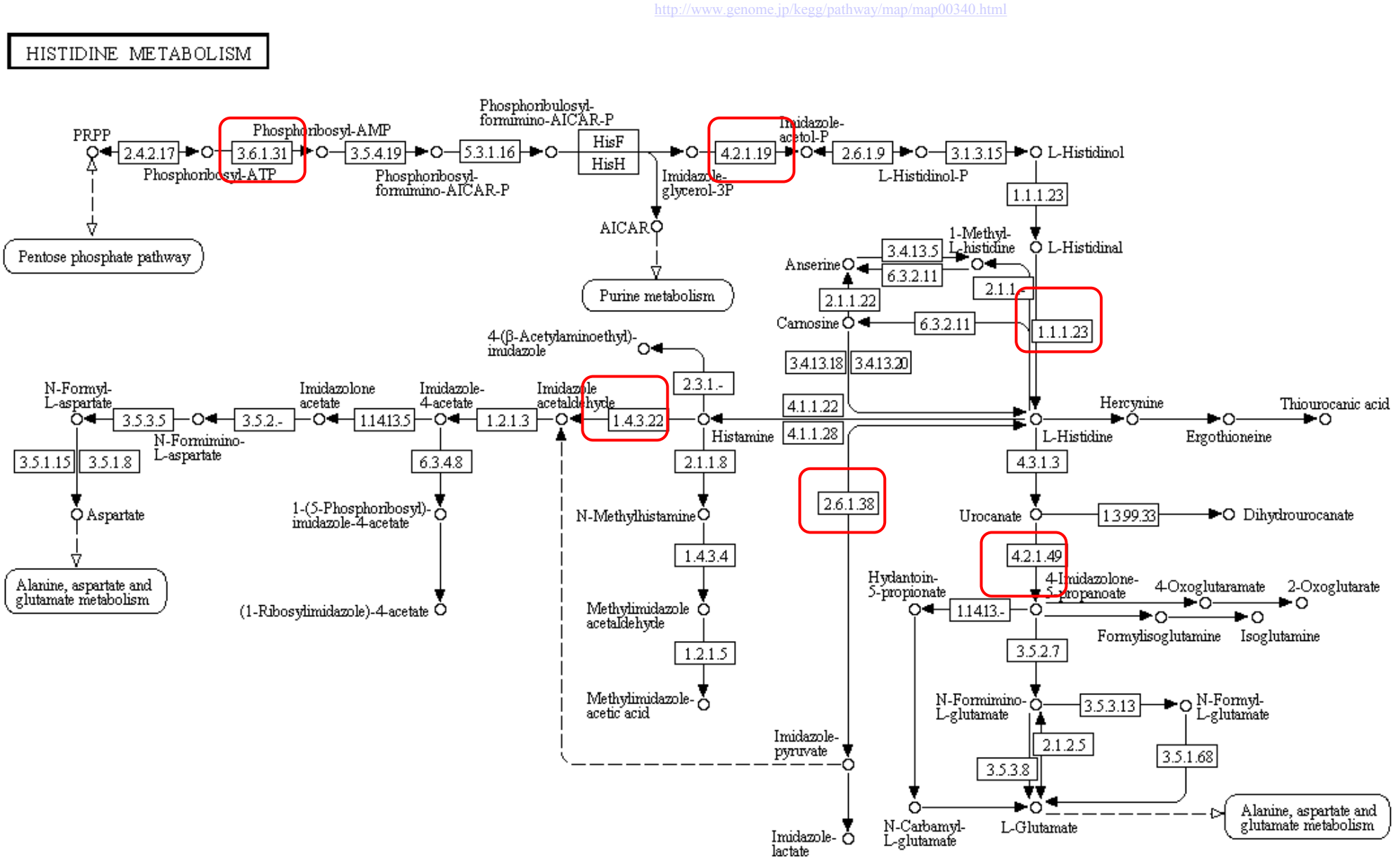


REFORMULATE THE CQs AND ADD LINKING AXIOMS

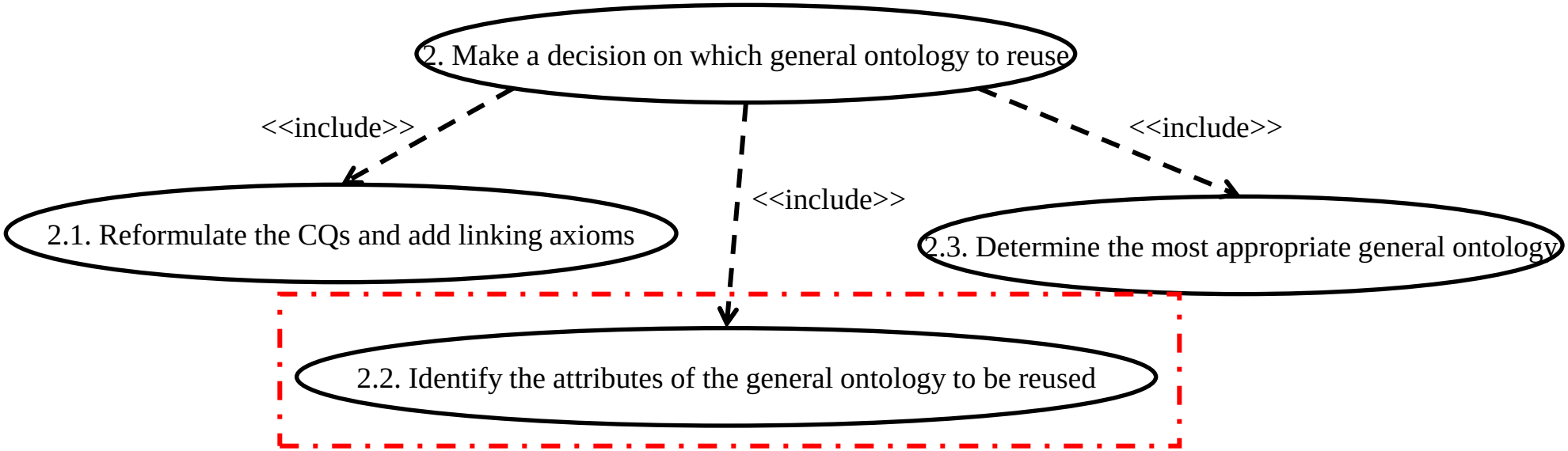
Heuristic 12 (time points). If we are not interested in the endpoints of the temporal entity returned by the CQ, then we should introduce a linking axiom in the general ontology to relate a domain ontology concept to time points.

When was Regulaten ® (a particular drug) registered?

Heuristic 13 (time intervals). If we are interested in the endpoints of the temporal entity returned by the CQ, then we should introduce a linking axiom in the general ontology to relate a domain ontology concept to time intervals.

When did Regulaten ® go on sale?

IDENTIFY THE ATTRIBUTES OF THE GENERAL ONTOLOGY TO BE REUSED



IDENTIFY THE ATTRIBUTES OF THE GENERAL ONTOLOGY TO BE REUSED

Heuristic 14 (axioms always to be reused). If they can be implemented, we recommend reusing both the reflexivity and the antisymmetry of *part_of*, and the weak supplementation principle.
This heuristic has the purpose of ensuring the right meaning of *part_of* and *proper_part_of*.

Heuristic 15 (transitivity). Suppose that the ontology should model X that has parts $X_1, X_2, \ldots, X_n$, and some of these parts, e.g., X_i has parts $X_{i1}, X_{i2}, \ldots, X_{im}$, that is, X has several levels of parts. Besides, we want to know all the levels when we ask, *which are the parts of X?* In such a case, the transitivity axiom should be reused.

Heuristic 16 (reuse of definitions). The new terms appearing in the CQs after the reformulation proposed in Use Case 2.1 should be included in the general ontology.

Heuristic 17. Heuristic 16 is also valid for time.

Heuristic 18 (absolute time). If the CQ can be expressed as *When does X happen?*, then the ontology should model absolute time (by means of time units).

Heuristic 19 (relations between time entities). If the CQ can be expressed such as *Does X happen before Y?, Does X happen after Y?*, *Does X happen at the same time as Y?* among others, where X and Y are time entities or events, then the ontology should model relations between time entities.

Heuristic 20 (relative time). If the CQ can be expressed according to the pattern of Heuristic 19, where, X and Y are events, then the ontology should model relative time.

THE INTEREST OF HEURISTIC 14

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THE INTEREST OF HEURISTIC 14

This transformation works because the relation part_of is reflexive. If the data that we are is that PI headquarters are located in Spain, we need the reflexivity

Are Pharmacia Iberia ® headquarters located in Spain?

Are Pharmacia Iberia ® headquarters located in some **part** of Spain?

THE INTEREST OF HEURISTIC 15 (TRANSITIVITY)

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Heuristic 16 (reuse of definitions). The new terms appearing in the CQs after the reformulation proposed in Use Case 2.1 should be included in the general ontology.

Heuristic 17. Heuristic 16 is also valid for time.

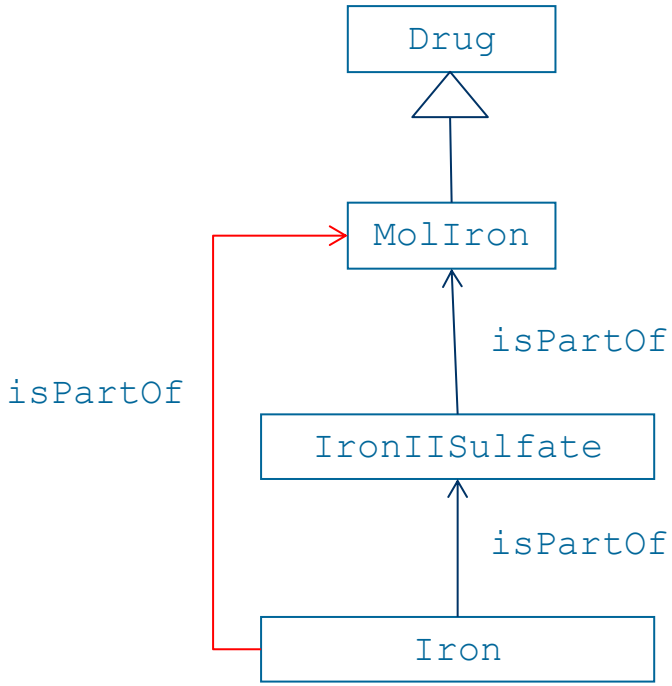
Heuristic 18 (absolute time). If the CQ can be expressed as *When does X happen?*, then the ontology should model absolute time (by means of time units).

Heuristic 19 (relations between time entities). If the CQ can be expressed such as *Does X happen before Y?, Does X happen after Y?*, *Does X happen at the same time as Y?* among others, where X and Y are time entities or events, then the ontology should model relations between time entities.

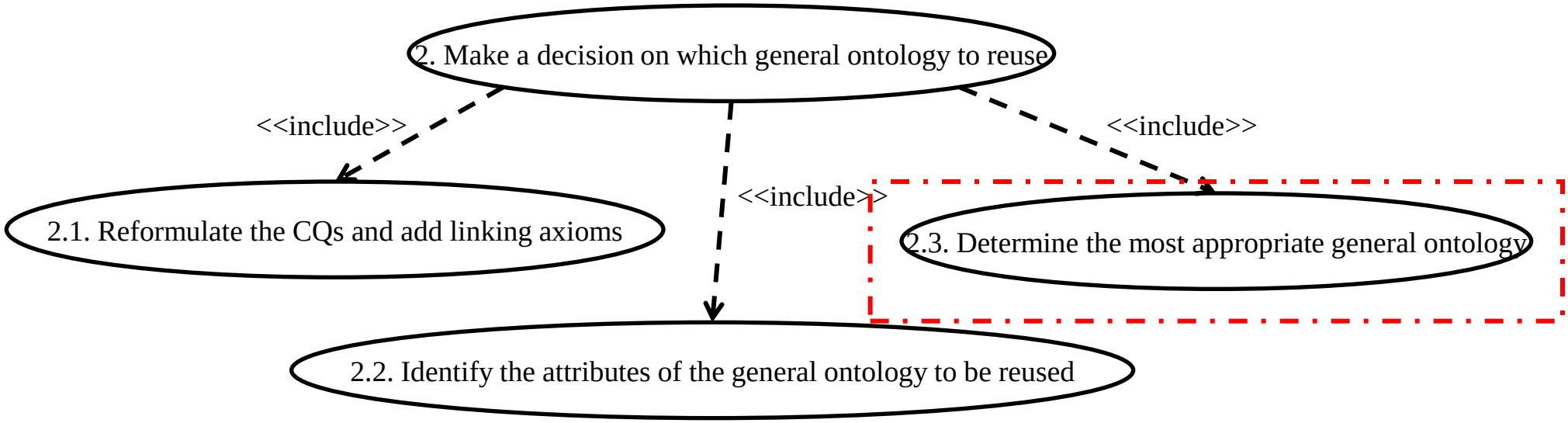
Heuristic 20 (relative time). If the CQ can be expressed according to the pattern of Heuristic 19, where, X and Y are events, then the ontology should model relative time.

THE INTEREST OF HEURISTIC 15 (TRANSITIVITY)

Does Mol Iron contain iron?



DETERMINE THE MOST APPROPRIATE GENERAL ONTOLOGY



FEATURES TO TAKE INTO ACCOUNT

Reuse Cost.
- *Reuse Financial Cost.*
- *Required Reuse Time.*

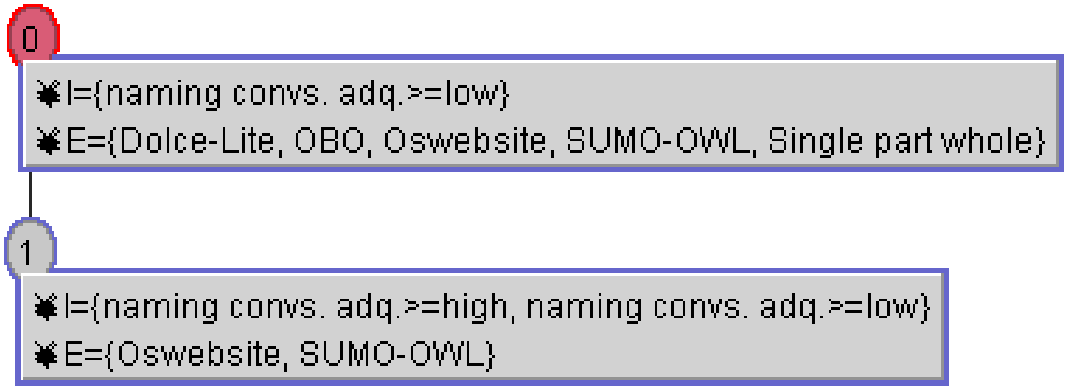
Understandability Effort.
- *Documentation quality.*
- *External knowledge source availability.*
- *Code clarity.*

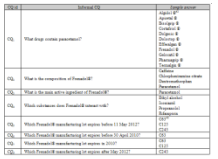
Integration Effort.
- *Knowledge extraction adequacy.*
- *Naming conventions adequacy.*
- *Implementation language adequacy.*
- *Knowledge clash.*
- *Adaptation to the reasoner.*
- *Need for bridge terms.*

Reliability.
- *Design criteria.*
- *Test availability.*
- *Former evaluation.*
- *Theoretical support.*
- *Development team reputation.*
- *Fitness for purpose.*
- *Practical support.*

EXAMPLE. INTEGRATION EFFORT LATTICE

Integration effort	knowledge extraction adequacy	naming conventions adequacy	implementation language adequacy
Single part whole	[high]	[low]	[high]
SUMO-OWL	[high]	[high]	[high]
Dolce-Lite	[high]	[low]	[high]
Oswebsite	[high]	[high]	[high]
OBO	[high]	[low]	[high]



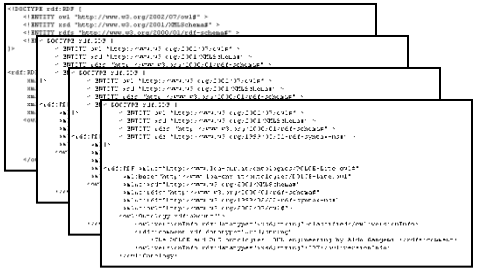


ORSD

1. Conduct a comparative study of reusable general ontologies

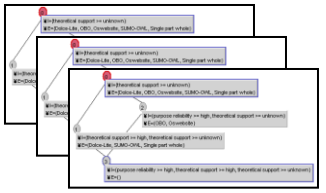
Functional features	A.1) Reflexivity	A.2) Antisymmetry	A.3) Transitivity	D.1) Proper part	A.4) Weak supplementation
Single part whole	0	0	X	0	0
SUMO-OWL	0	0	0	X	0
Dolce-Lite	0	0	0	X	0
Oswebsite	0	0	X	0	0
OBO	0	0	X	X	0

Formal concept representing the comparative study



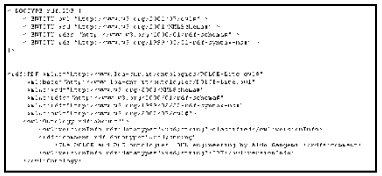
General ontologies

2. Make a decision on which general ontology to reuse

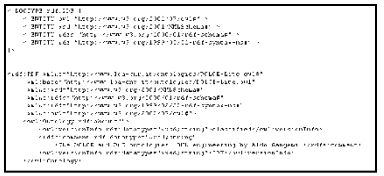


Lattices to determine the most appropriate ontology

3. Assemble the whole ontology

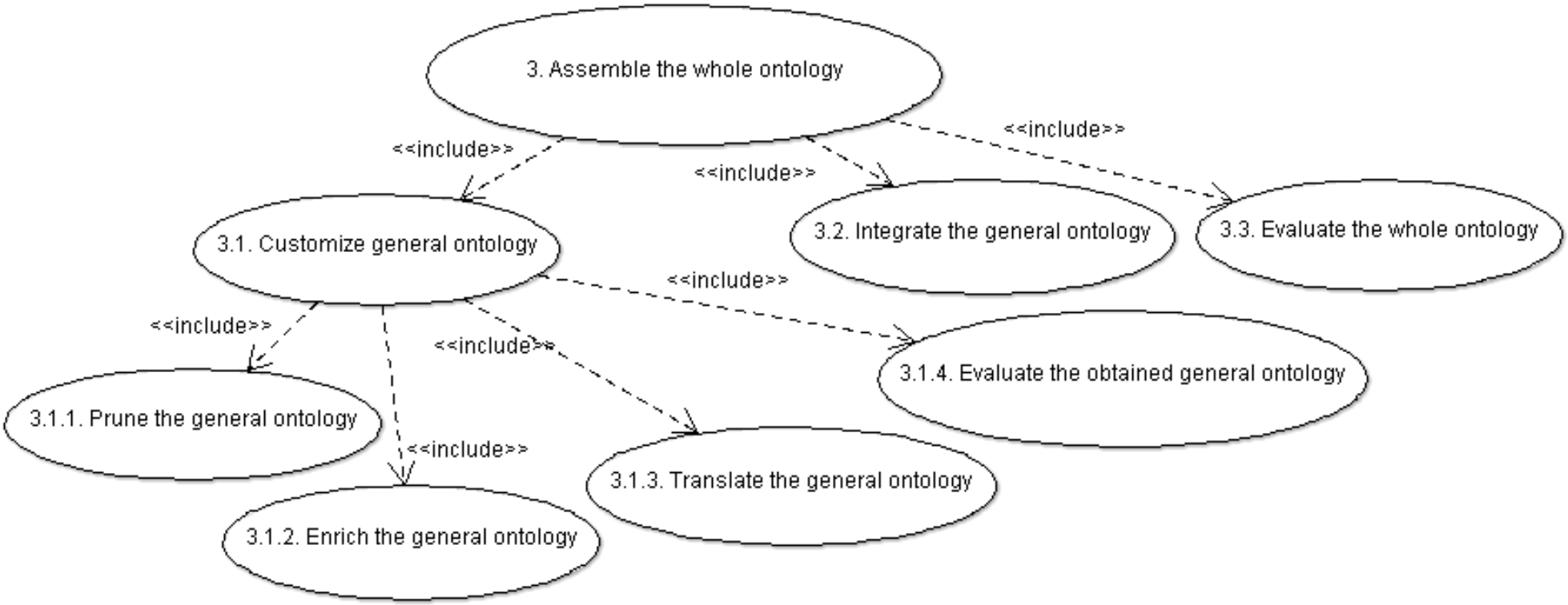


Assembled whole ontology

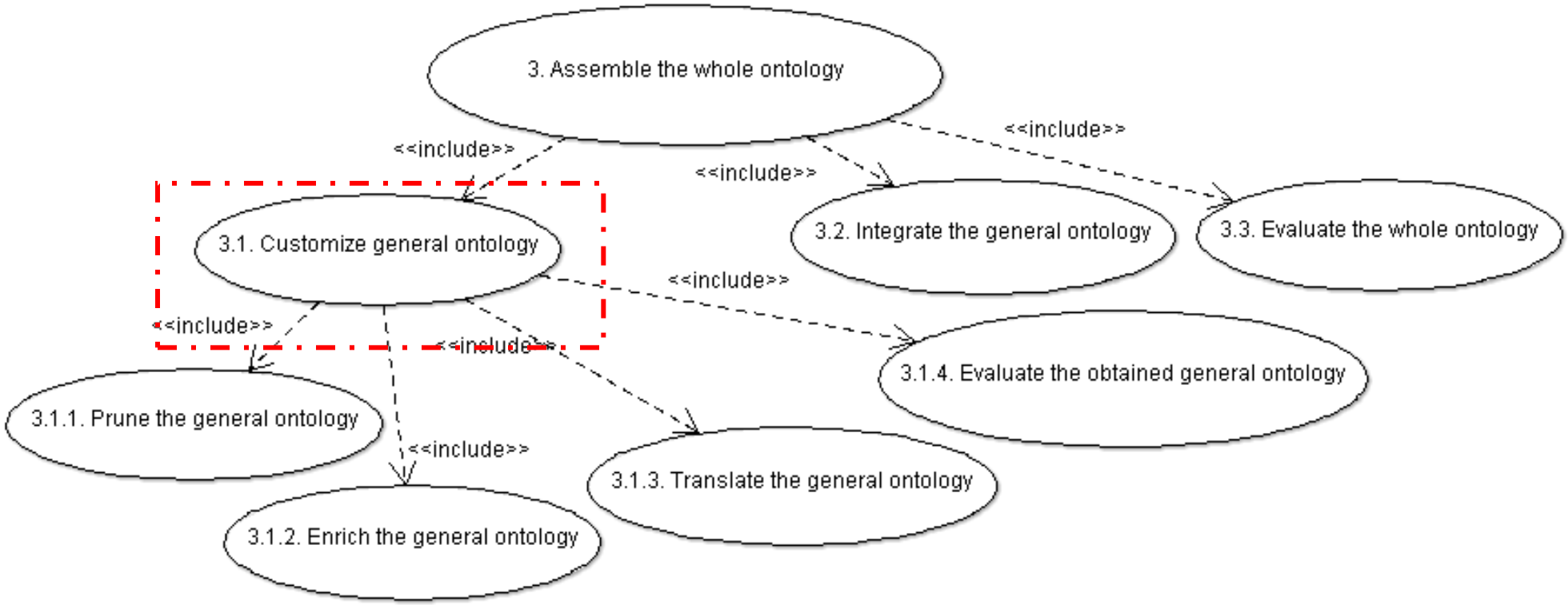


Choosen a general ontology

ASSEMBLE THE WHOLE ONTOLOGY

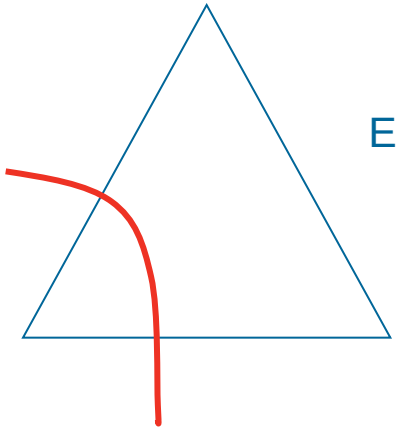


CUSTOMIZE GENERAL ONTOLOGY

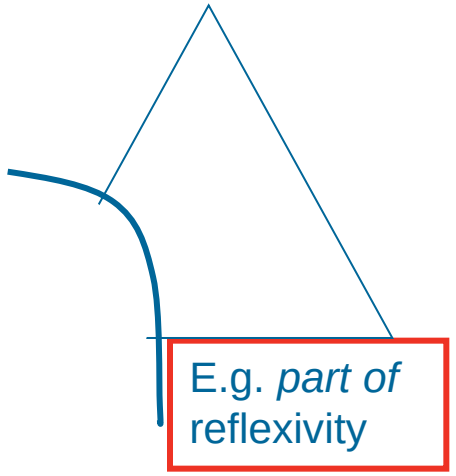


CUSTOMIZE GENERAL ONTOLOGY

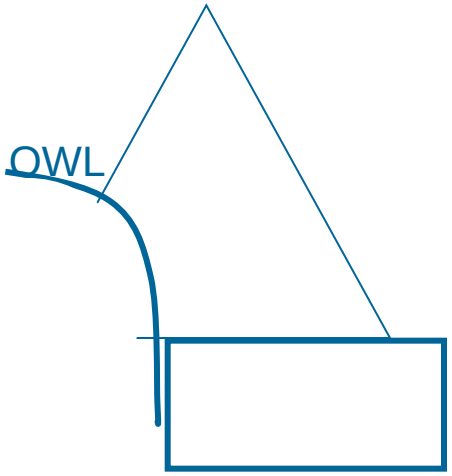
Pruning the MO (e.g. the relation *overlap* is not necessary in our domain ontology)



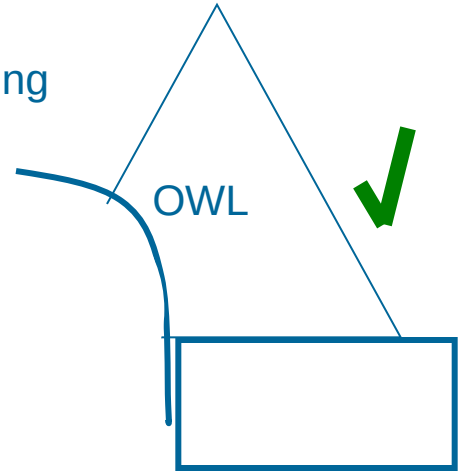
Enriching the MO



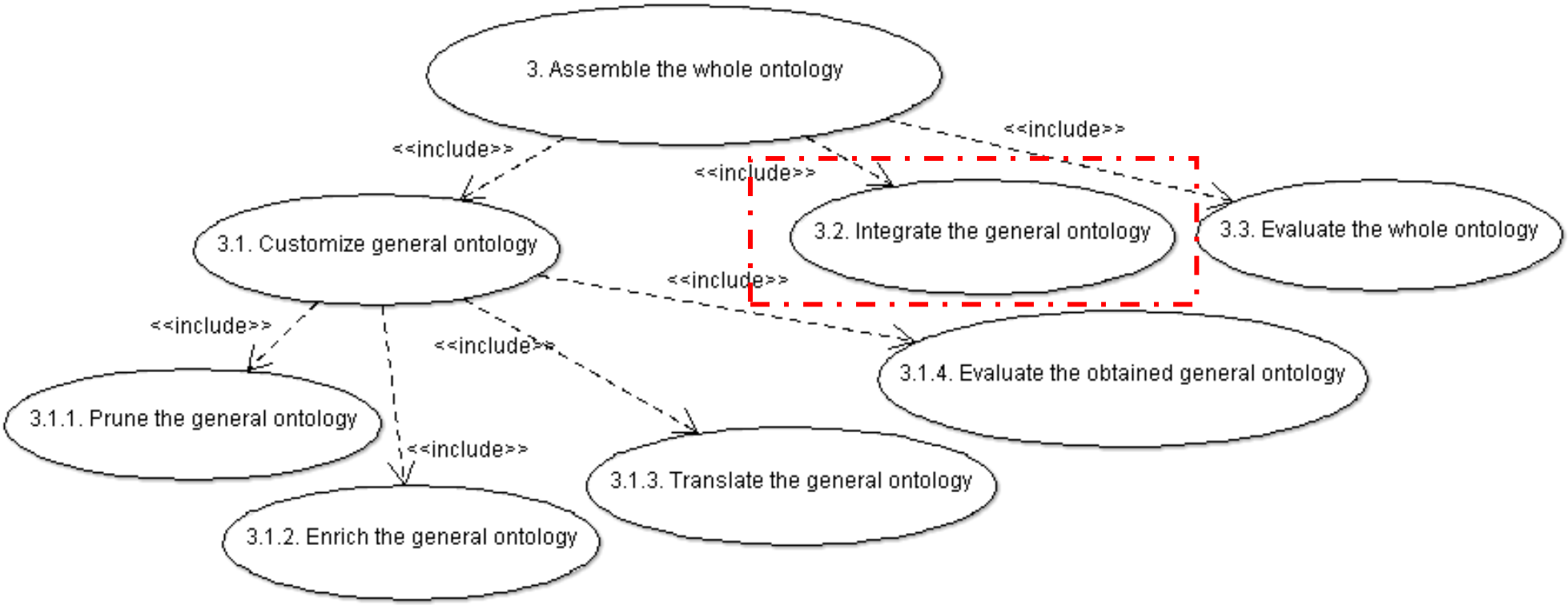
Translating into OWL



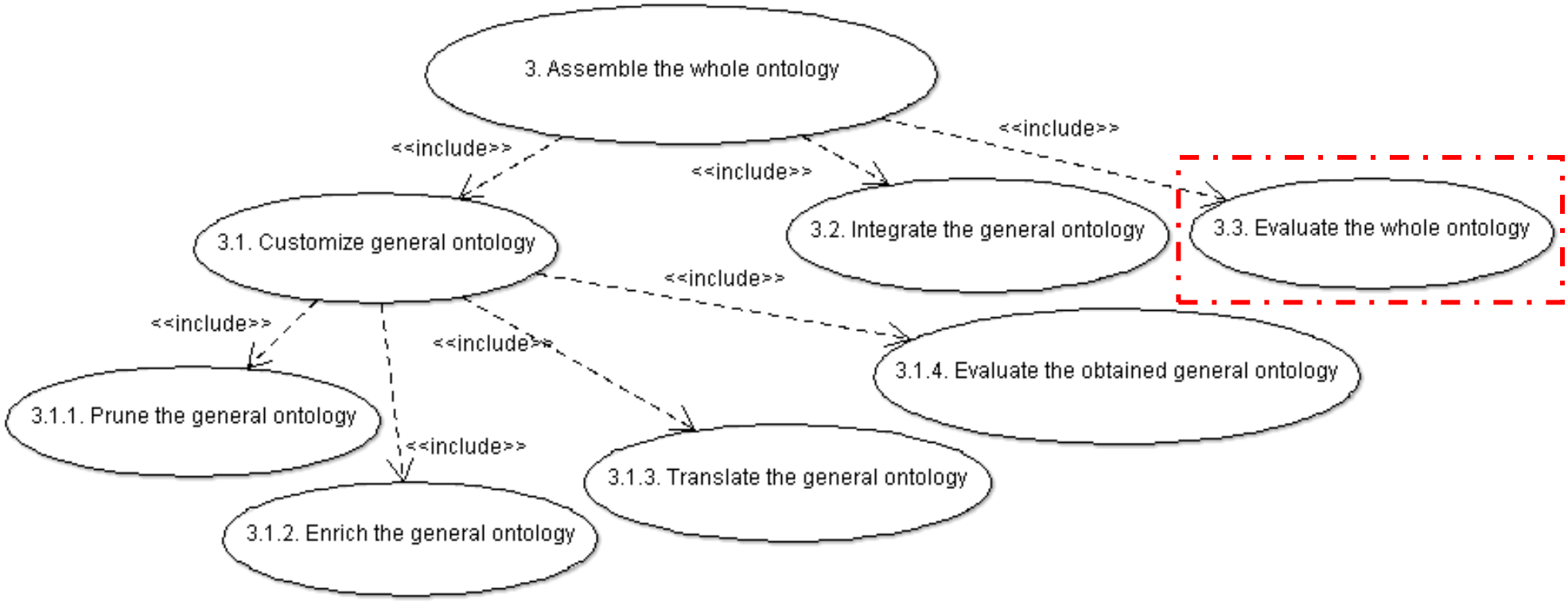
Evaluating



INTEGRATE THE GENERAL ONTOLOGY

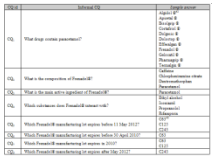


EVALUATE THE GENERAL ONTOLOGY



STUDY CASE

CQ id	Informal CQ	Sample answer
CQ_1	Which drugs contain paracetamol?	Algidol ® Apiretal ® Bisolgrip ® Cortafriol ® Dolgesic ® Dolostop ® Efferalgan ® Frenadol ® Gelocatil ® Pharmagrip ® Termalgin ®
CQ_2	What is the composition of Frenadol®?	Caffeine Chlorpheniramine citrate Dextromethorphan Paracetamol
CQ_3	What is the main active ingredient of Frenadol®?	Paracetamol
CQ_4	With which substances does Frenadol® interact?	Ethyl alcohol Isoniazid Propranolol Rifampicin
CQ_5	Which Frenadol® manufacturing lot expires before 11 May 2012?	C63 C125 C243
CQ_6	Which Frenadol® manufacturing lot expires before 30 April 2010?	C63
CQ_7	Which Frenadol® manufacturing lot expires in 2010?	C63 C125
CQ_8	Which Frenadol® manufacturing lot expires after May 2012?	C243

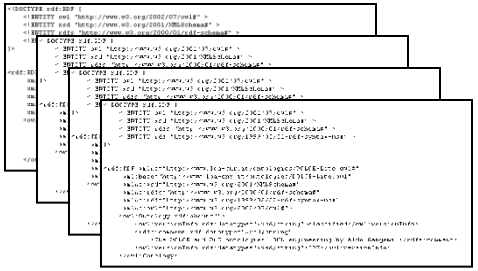


ORSD

1. Conduct a comparative study of reusable general ontologies

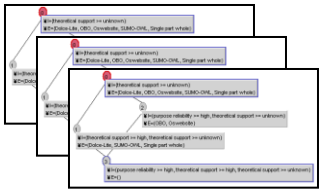
Functional features	A.1) Reflexivity	A.2) Antisymmetry	A.3) Transitivity	D.1) Proper part	A.4) Weak supplementation
Single part whole	0	0	X	0	0
SUMO-OWL	0	0	0	X	0
Dolce-Lite	0	0	0	X	0
Oswebsite	0	0	X	0	0
OBO	0	0	X	X	0

Formal concept representing the comparative study



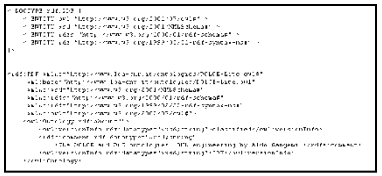
General ontologies

2. Make a decision on which general ontology to reuse

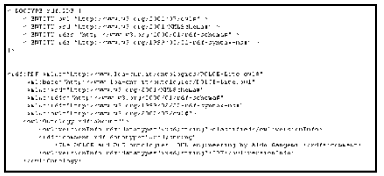


Lattices to determine the most appropriate ontology

3. Assemble the whole ontology

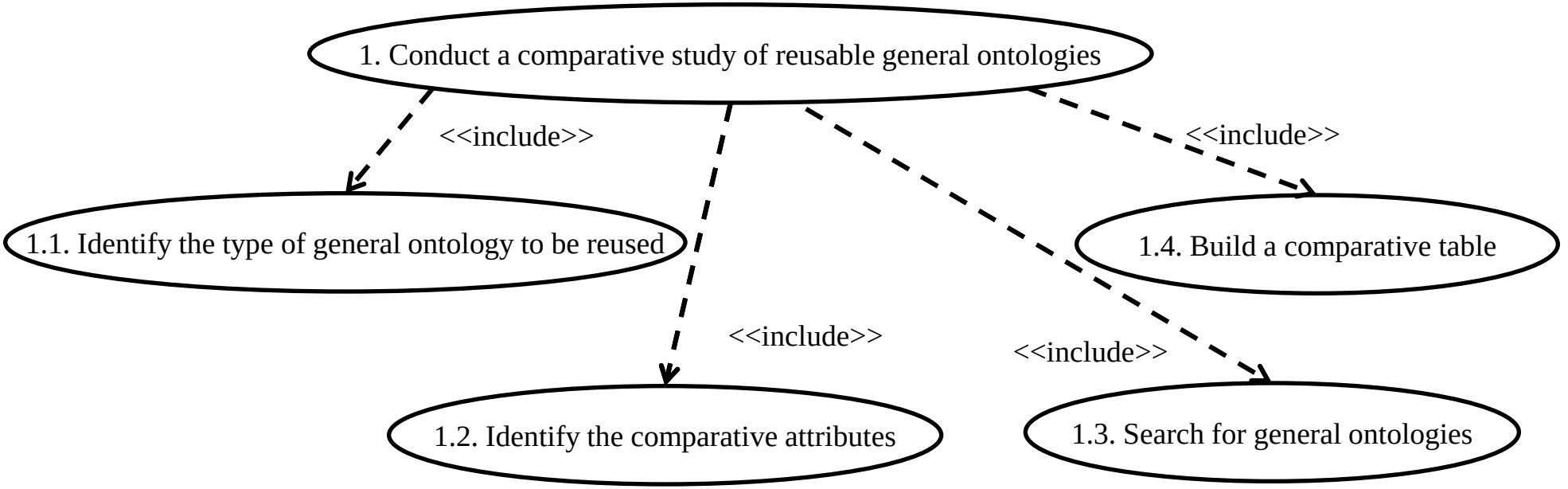


Assembled whole ontology



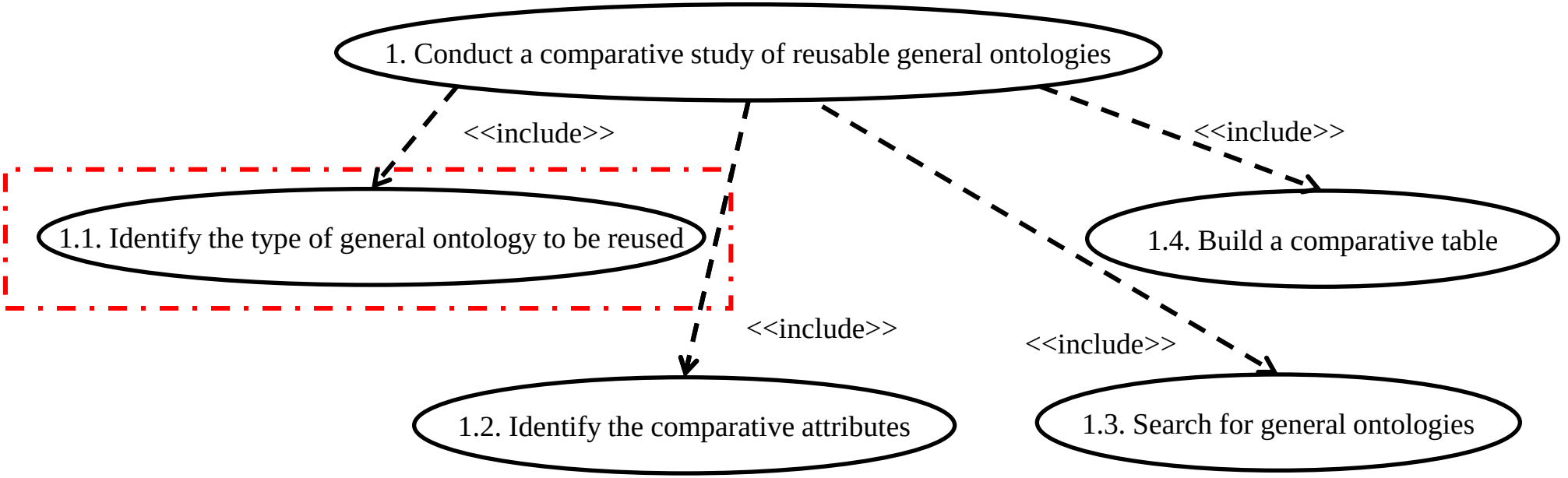
Choosen a general ontology

STUDY CASE. CONDUCT A COMPARATIVE STUDY OF REUSABLE GENERAL ONTOLOGIES



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

STUDY CASE. IDENTIFY THE TYPE OF GENERAL ONTOLOGY TO BE REUSED



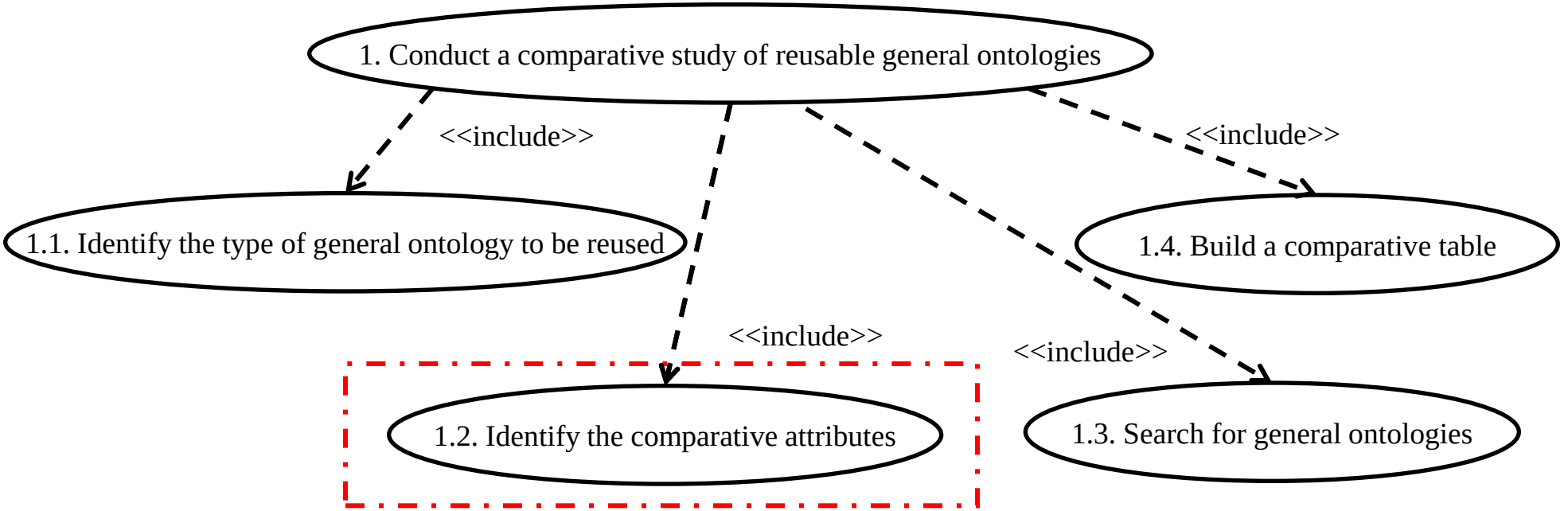
ArgoUML has been used to draw the UML diagrams of this presentation

STUDY CASE

CQ identifier	Application of heuristics	Type of general ontology for reuse
CQ_1 (Which drugs contain paracetamol?) and CQ_2 (Which drugs contain paracetamol?)	Heuristic 1. This competency question is asking for structural parts.	**Mereology**
CQ_3 (What is the main active ingredient of Frenadol®?)	Heuristic 2. Every active ingredient of a drug is a structural part of the drug. Therefore, main_active_ingredient_of is a sub-relation of *part_of*.	**Mereology**
CQ_4 (With which substances does Frenadol® interact?)	Heuristic 1. To find out whether a drug interacts with other substances, it is necessary to know the interaction of each of its structural parts with other substances.	**Mereology**
CQ_5, CQ_6, CQ_7 and CQ_8	Heuristic 3.There are specialized time patterns: 11 May 2012, 30 April 2010 There is a preposition of time: before.	**Time modelling**

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

STUDY CASE. IDENTIFY THE COMPARATIVE ATTRIBUTES



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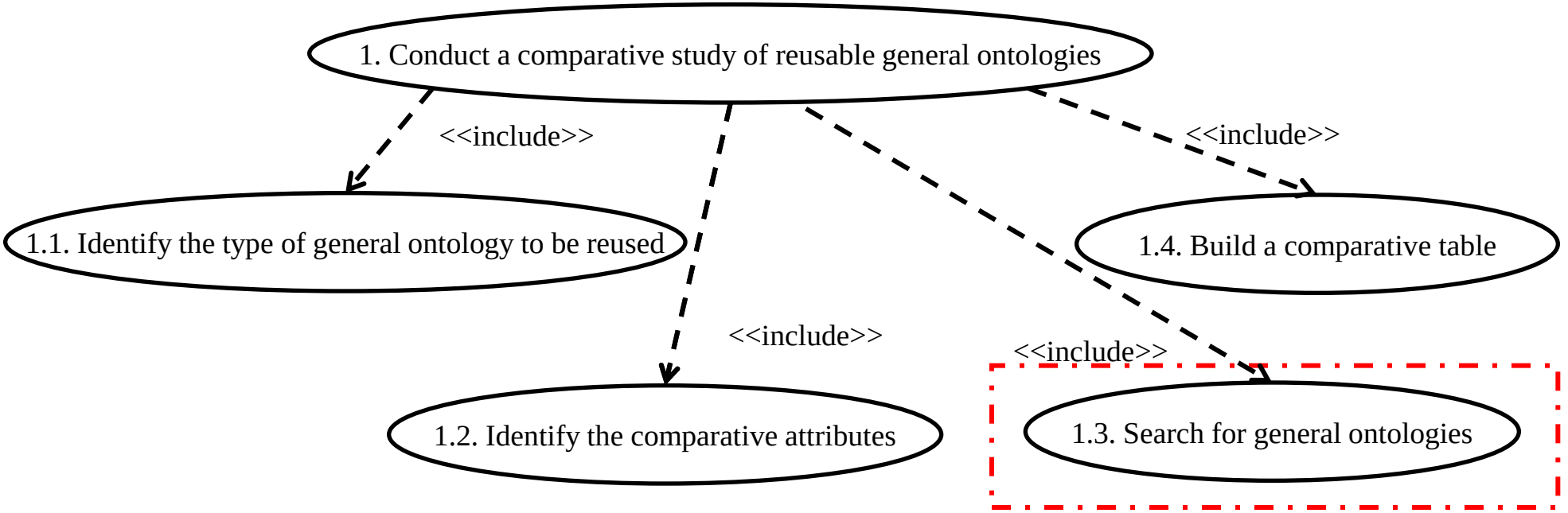
STUDY CASE. SEARCH FOR GENERAL ONTOLOGIES



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

STUDY CASE. SEARCHING FOR ONTOLOGIES

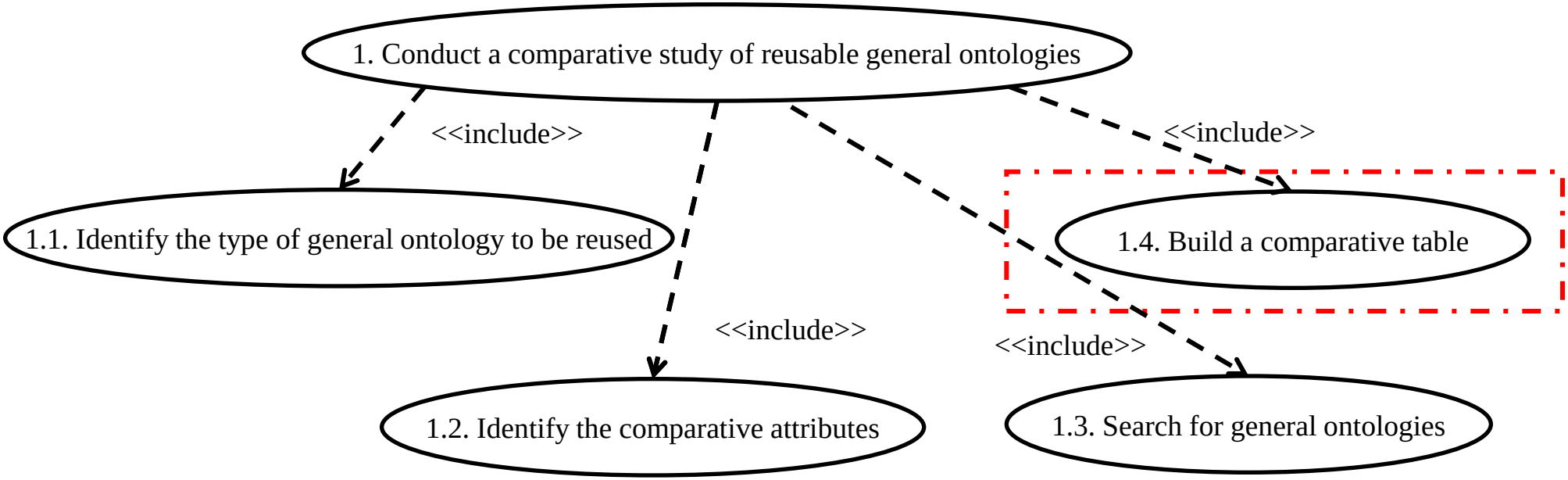
We can use:

- **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.).

Identified ontologies	Project or institution	General theory
Single part whole	W3C	Mereology
SUMO-OWL	IEEE Standard Upper Ontology working group	Mereology Time
DOLCE-Lite	Italian Research Council (CNR)	Mereology Time
Oswebsite	OS Open data	Mereology
OBO	Open Biological and Biomedical Ontologies	Mereology
OWL-Time	W3C	Time
AKT-Time	Advanced Knowledge Technologies (AKT)	Time

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

STUDY CASE. BUILD A COMPARATIVE TABLE



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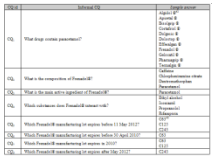
STUDY CASE. BUILD A COMPARATIVE TABLE

Functional features	A.1) Reflexivity	A.2) Antisymmetry	A.3) Transitivity	D.1) Proper part	A.4) Weak supplementation
Single part whole	0	0	X	0	0
SUMO-OWL	0	0	0	X	0
Dolce-Lite	0	0	X	X	0
Oswebsite	0	0	X	0	0
OBO	0	0	X	X	0

Functional features	Time points	Time intervals	Absolute time	Relations between temporal entities	Modeling of conv...	Modeling of...
OWL-Time	X	X	X	X	X	0
SUMO-OWL	X	X	0	X	0	0
AKT-Time	X	X	X	0	X	0



ORSD

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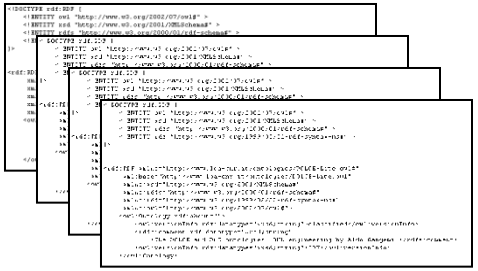
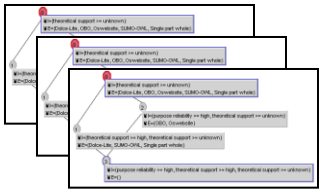
Formal concept representing the comparative study



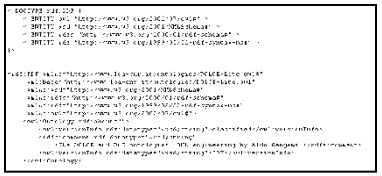
General ontologies

2. Make a decision on which general ontology to reuse

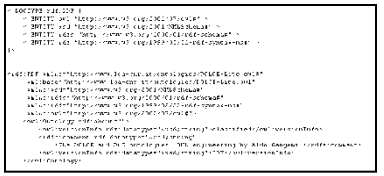


Lattices to determine the most appropriate ontology

3. Assemble the whole ontology

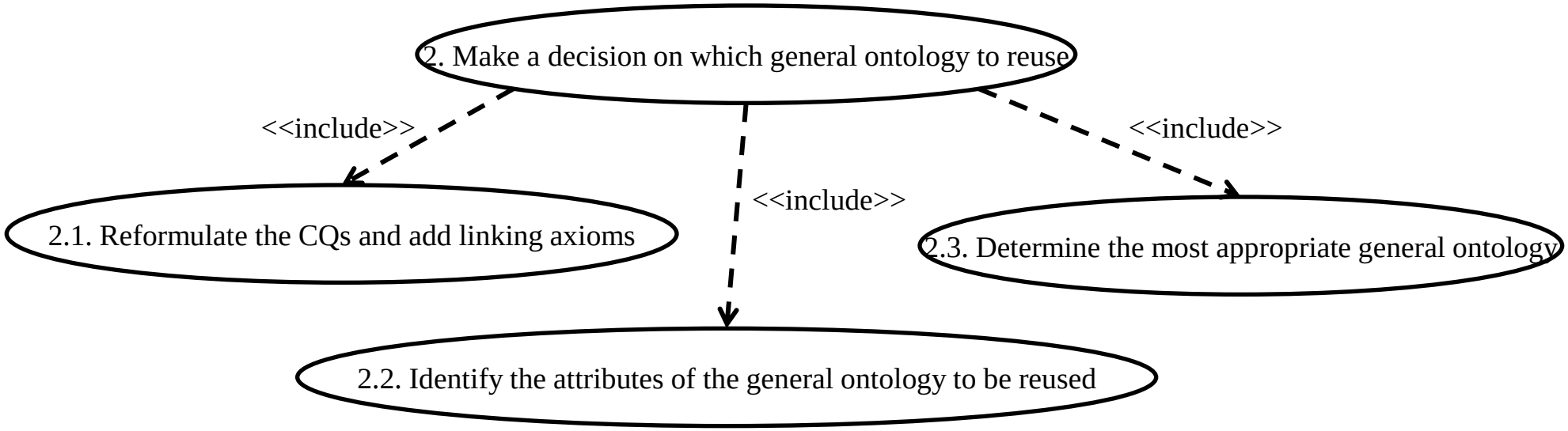


Assembled whole ontology

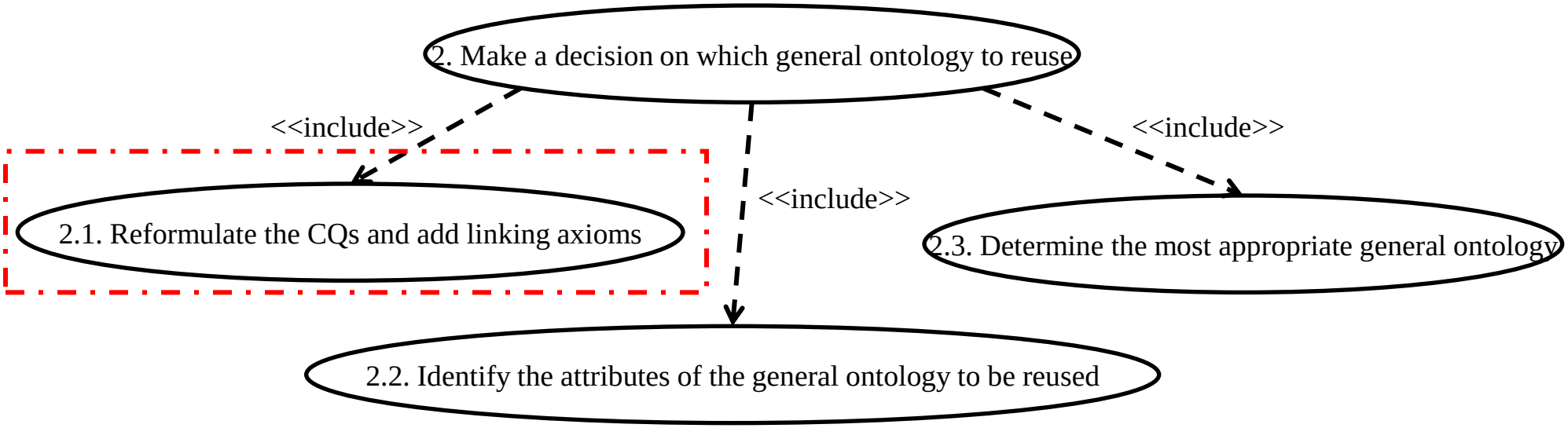


Choosen a general ontology

STUDY CASE. MAKE A DECISION ON WHICH GENERAL ONTOLOGY TO REUSE



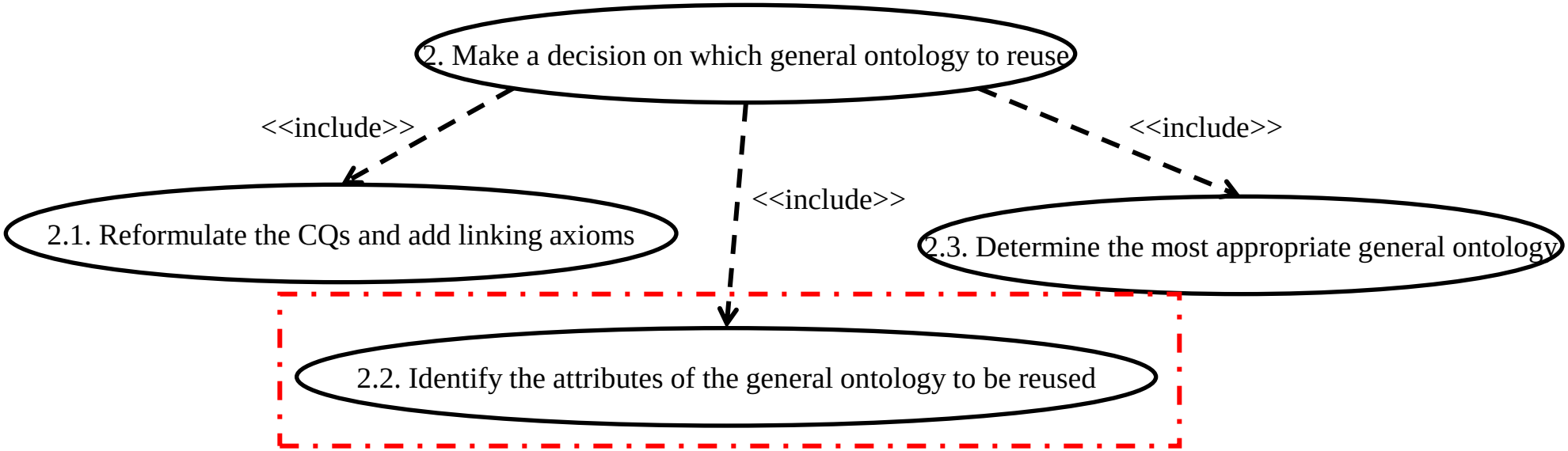
STUDY CASE. REFORMULATE THE CQs AND ADD LINKING AXIOMS



REFORMULATE THE CQs AND ADD LINKING AXIOMS

Heuristic	Competency question	Action	Result of the action
Heuristic 7. We want to know the parts of an object not including the actual object.	CQ_2) What is the composition of Frenadol®?	Reformulate the CQ to include the term is proper part of.	Which are the proper parts of Frenadol®?
Heuristic 9. We want to know the parts of an object, including the actual object.	CQ_1) Which drugs contain paracetamol? (The actual substance is included because the user could ask for a drug directly)	Reformulate the CQ to include the term is part of.	Which drugs is paracetamol part of?
	CQ_4) With which substances does Frenadol® interact?		With which substances do the parts of Frenadol® interact?
Heuristic 11. The CQ refers to a relation S that is a sub-relation of R that satisfies conditions CM_1 and CM_2.	CQ_3) Which is the main active ingredient of Frenadol®?	Add a linking axiom establishing that S is a subrelation of part_of.	Add the following axiom: "Main active ingredient of is a sub-relation of part_of."
Heuristic 12. We want to know which are the endpoints of the temporal entity returned by the CQ	CQ_5) Which drug manufacturing lot expires before 11 May 2012?	Add a linking axiom to time points.	Add the following axiom: "The range of has expiration date in the concept drug is time point."

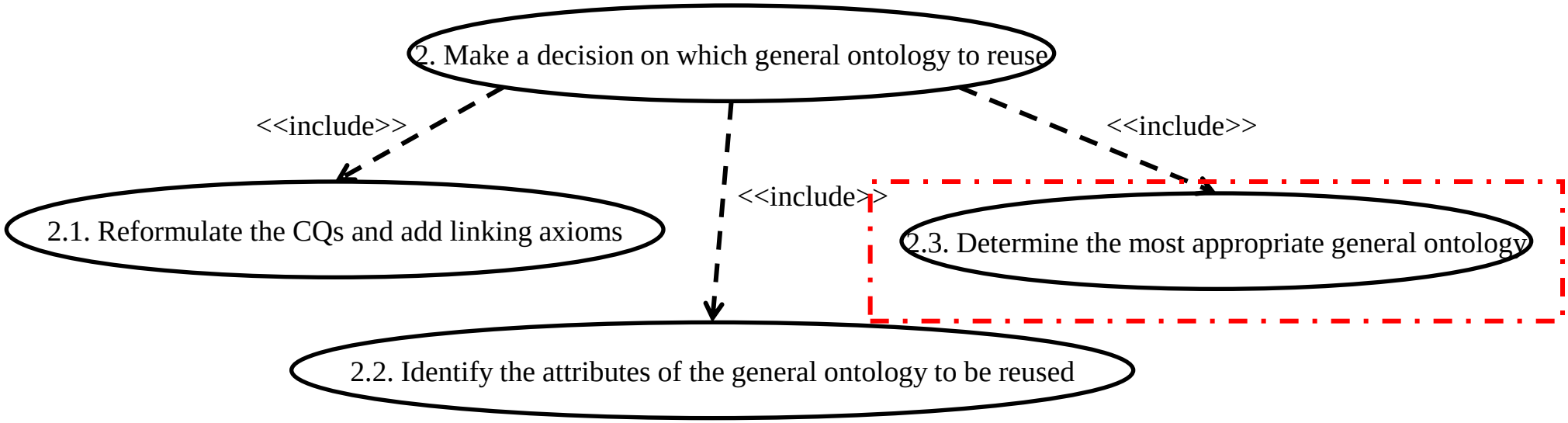
STUDY CASE. IDENTIFY THE ATTRIBUTES OF THE GENERAL ONTOLOGY TO BE REUSED



STUDY CASE. IDENTIFY THE ATTRIBUTES OF THE GENERAL ONTOLOGY TO BE REUSED

Axioms and definitions	Conditions established by heuristics	Are conditions met?
A.1) Reflexivity	Heuristic 14 condition: implementation is possible.	Yes
A.2) Antisymmetry	Heuristic 14 condition: implementation is possible.	Yes
A.3) Transitivity	Heuristic 15 condition: X has parts X_1, X_2, …, X_n, , and some X_i has parts X_{i1}, X_{i2}, …, X_{im}, that is, X has several levels of parts. Besides, we want to know all the levels when we ask, Which are the parts of X?	Yes
D.1) Proper part	Heuristic 16 condition for *proper_part* is met.	Yes
D.2) Direct part	Heuristic 16 condition for *direct_part* is met.	No
D.3) Overlap	Heuristic 16 condition for *overlap* is met.	No
D.4) Underlap	Heuristic 16 condition for *underlap* is met.	No
D.5) Disjoint	Heuristic 16 condition for *disjoint* is met.	No
A.4) Weak supplementation	Heuristic 14 condition: implementation is possible.	Yes

STUDY CASE. DETERMINE THE MOST APPROPRIATE GENERAL ONTOLOGY



STUDY CASE. FEATURES TO TAKE INTO ACCOUNT

Reuse Cost.
- *Reuse Financial Cost.*
- *Required Reuse Time.*

Understandability Effort.
- *Documentation quality.*
- *External knowledge source availability.*
- *Code clarity.*

Integration Effort.
- *Knowledge extraction adequacy.*
- *Naming conventions adequacy.*
- *Implementation language adequacy.*
- *Knowledge clash.*
- *Adaptation to the reasoner.*
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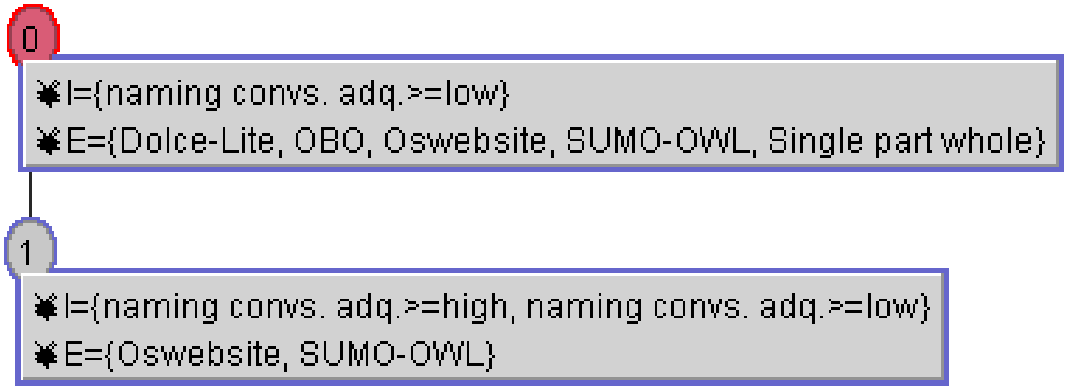
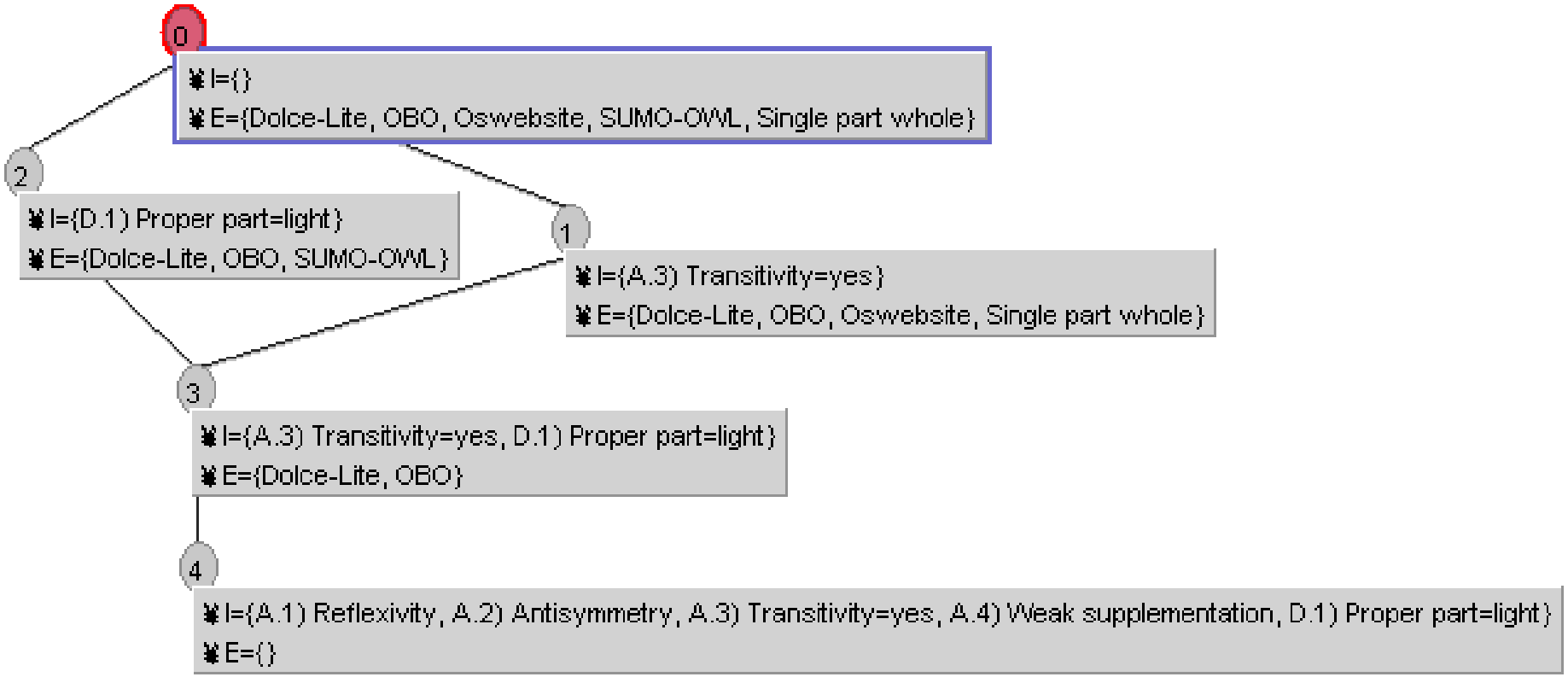
Reliability.
- *Design criteria.*
- *Test availability.*
- *Former evaluation.*
- *Theoretical support.*
- *Development team reputation.*
- *Fitness for purpose.*
- *Practical support.*

STUDY CASE. INTEGRATION EFFORT LATTICE

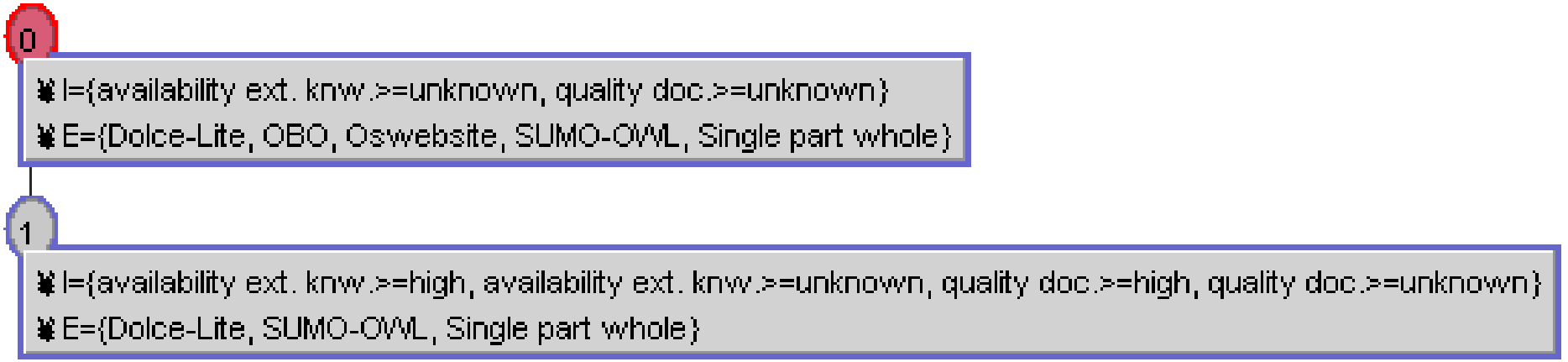
Integration effort	knowledge extraction adequacy	naming conventions adequacy	implementation language adequacy
Single part whole	[high]	[low]	[high]
SUMO-OWL	[high]	[high]	[high]
Dolce-Lite	[high]	[low]	[high]
Oswebsite	[high]	[high]	[high]
OBO	[high]	[low]	[high]



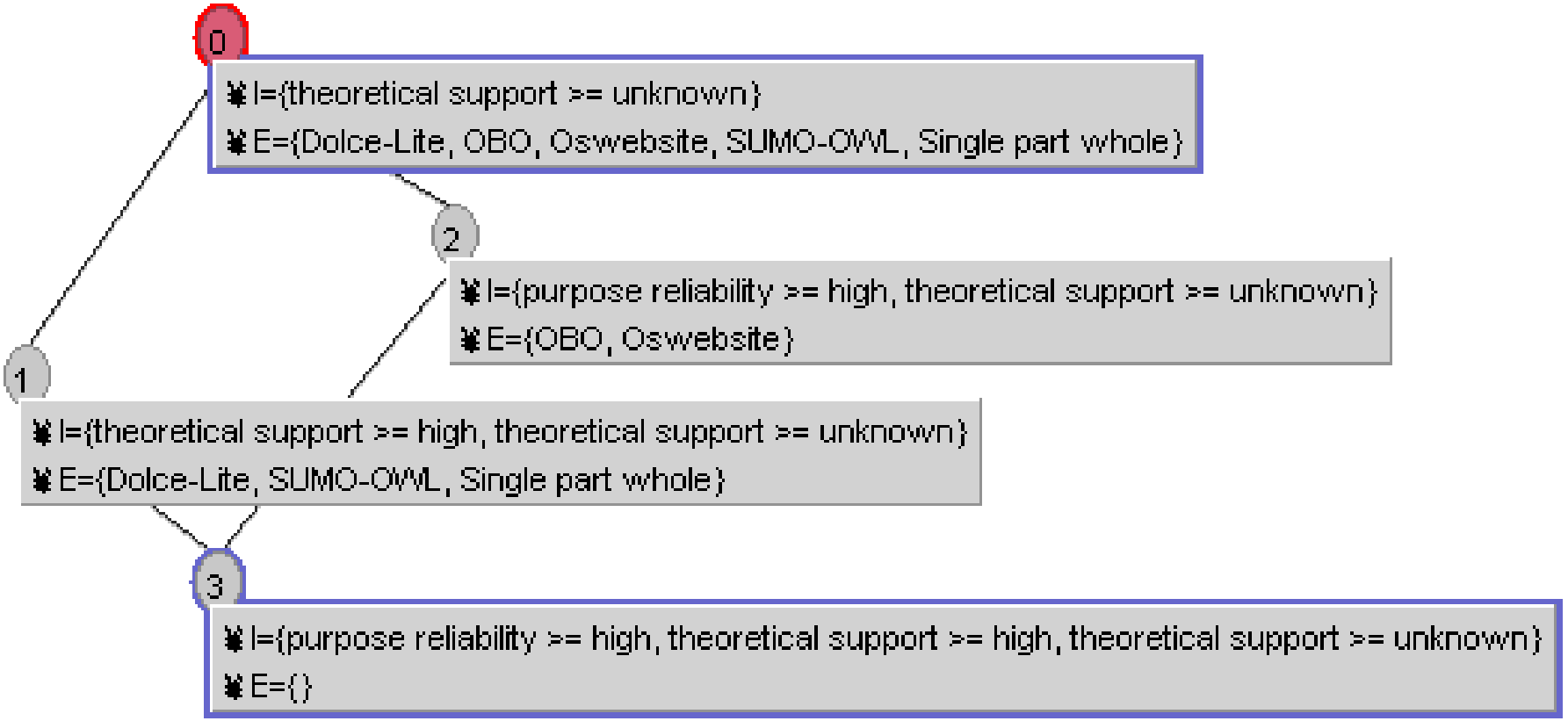
STUDY CASE. LATTICE OF AXIOMS AND DEFINITIONS



STUDY CASE. UNDERSTANDABILITY EFFORT LATTICE



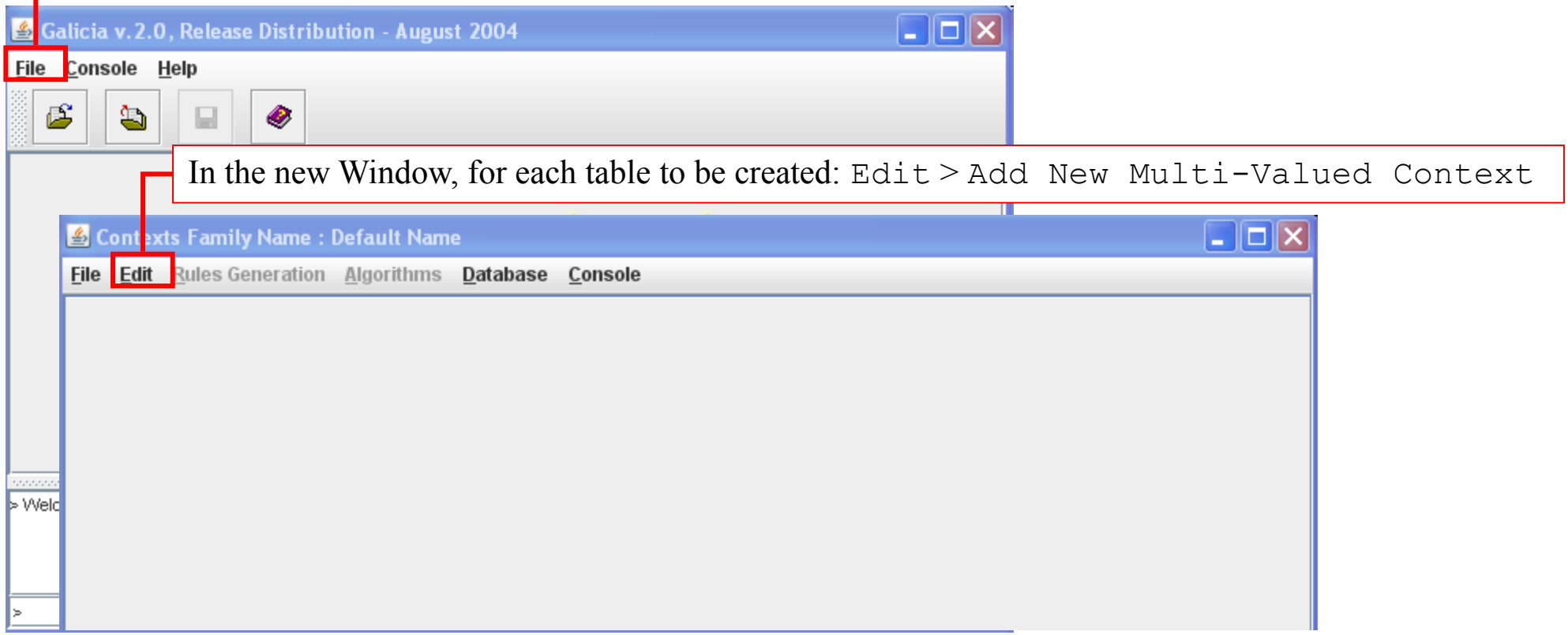
STUDY CASE. RELIABILITY LATTICE



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

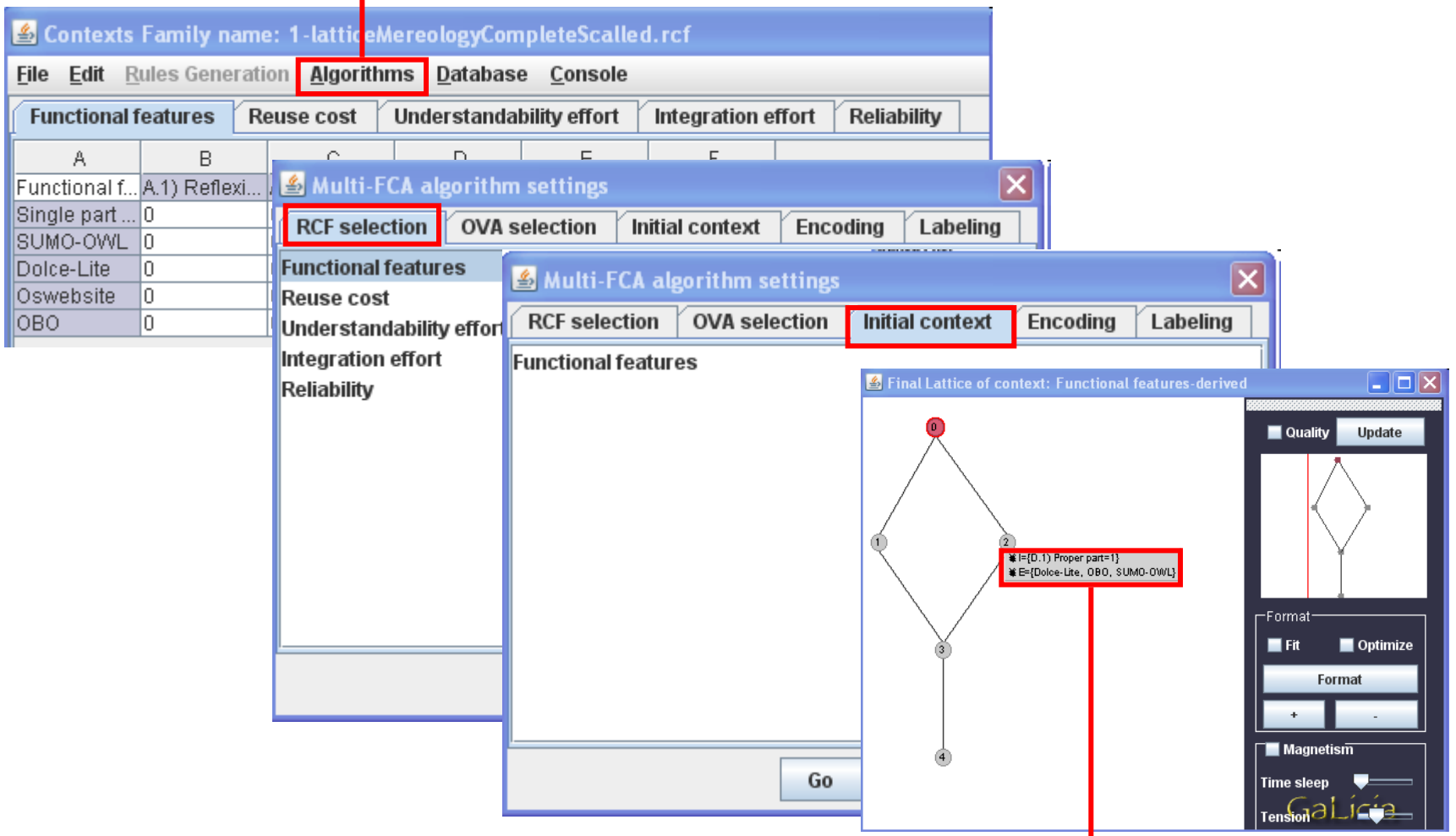
To download the tool: http://www.iro.umontreal.ca/~galicia/

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

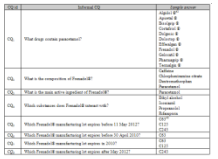


MULTI-FCA WITH GALICIA. HOW TO GENERATE A LATTICE

Algorithms > Multi-FCA > Interactive Multi-FCA

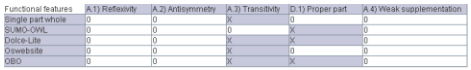


This information is obtained clicking the right button of the mouse

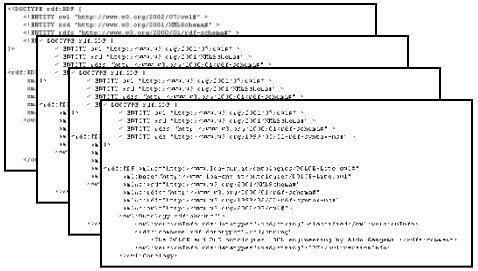


ORSD

1. Conduct a comparative study of reusable general ontologies

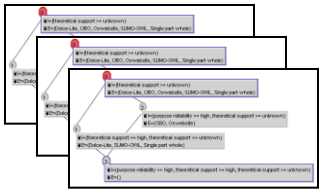


Formal concept representing the comparative study



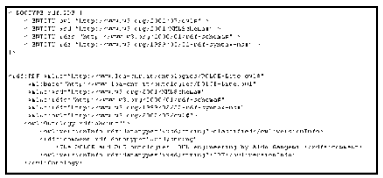
General ontologies

2. Make a decision on which general ontology to reuse

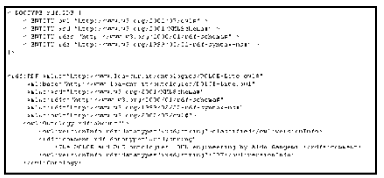


Lattices to determine the most appropriate ontology

3. Assemble the whole ontology

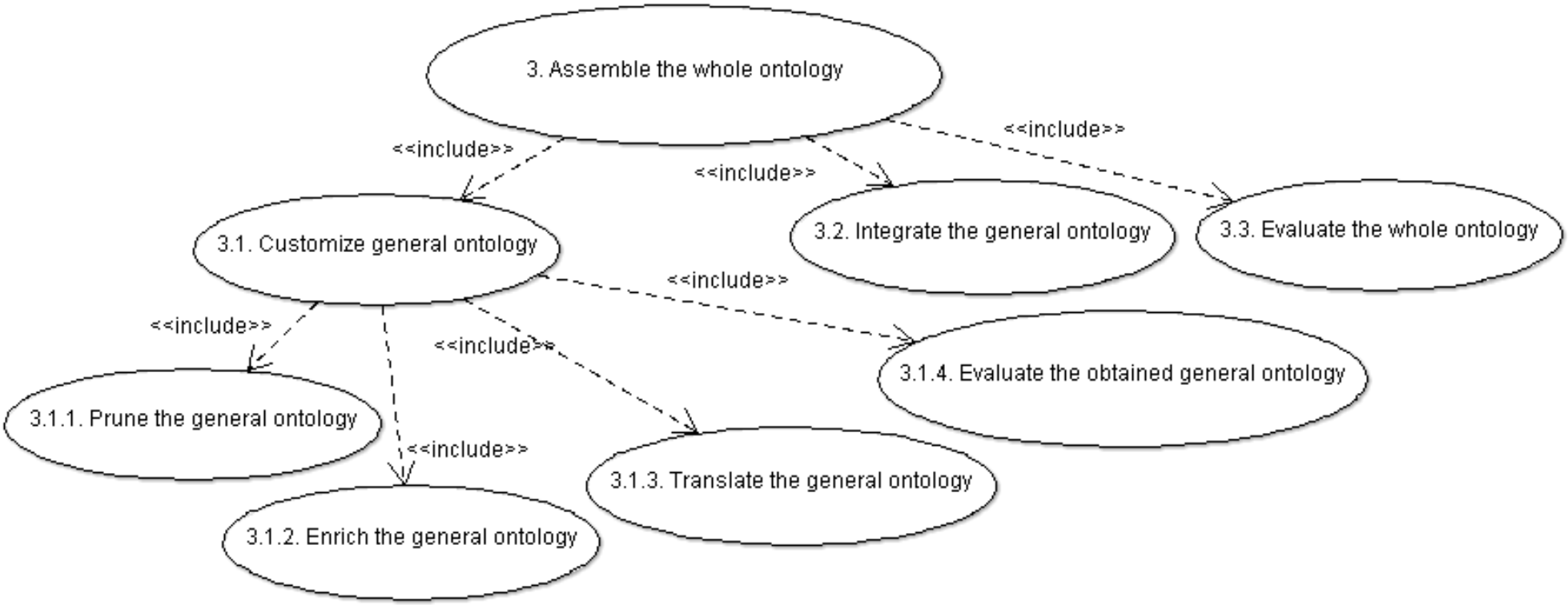


Assembled whole ontology

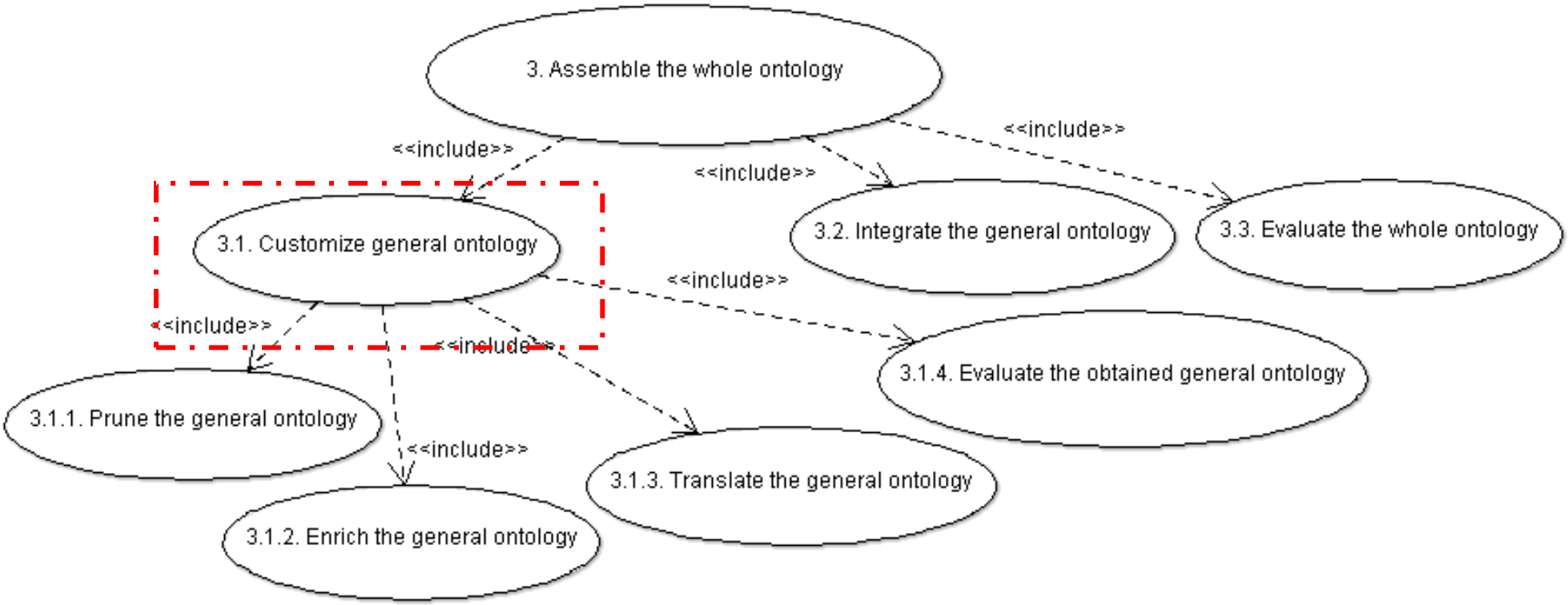


Choosen a general ontology

STUDY CASE. ASSEMBLE THE WHOLE ONTOLOGY

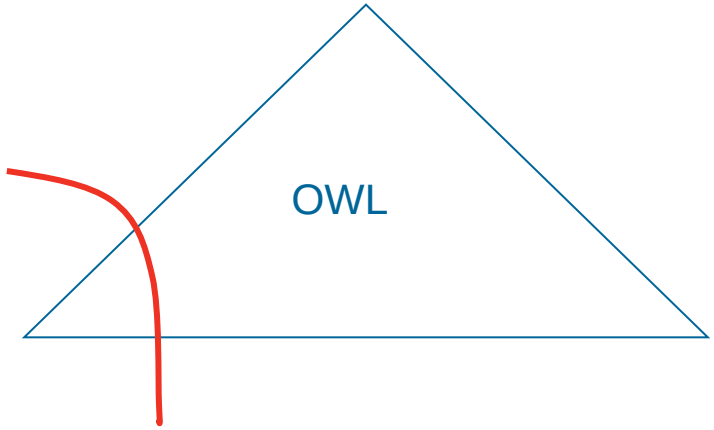


STUDY CASE. CUSTOMIZE GENERAL ONTOLOGY



STUDY CASE. CUSTOMIZE GENERAL ONTOLOGY

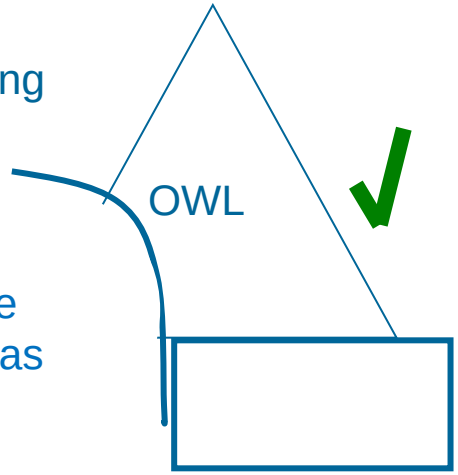
Pruning the MO (e.g. the relation *overlap* is not necessary in our domain ontology)



Enriching the MO

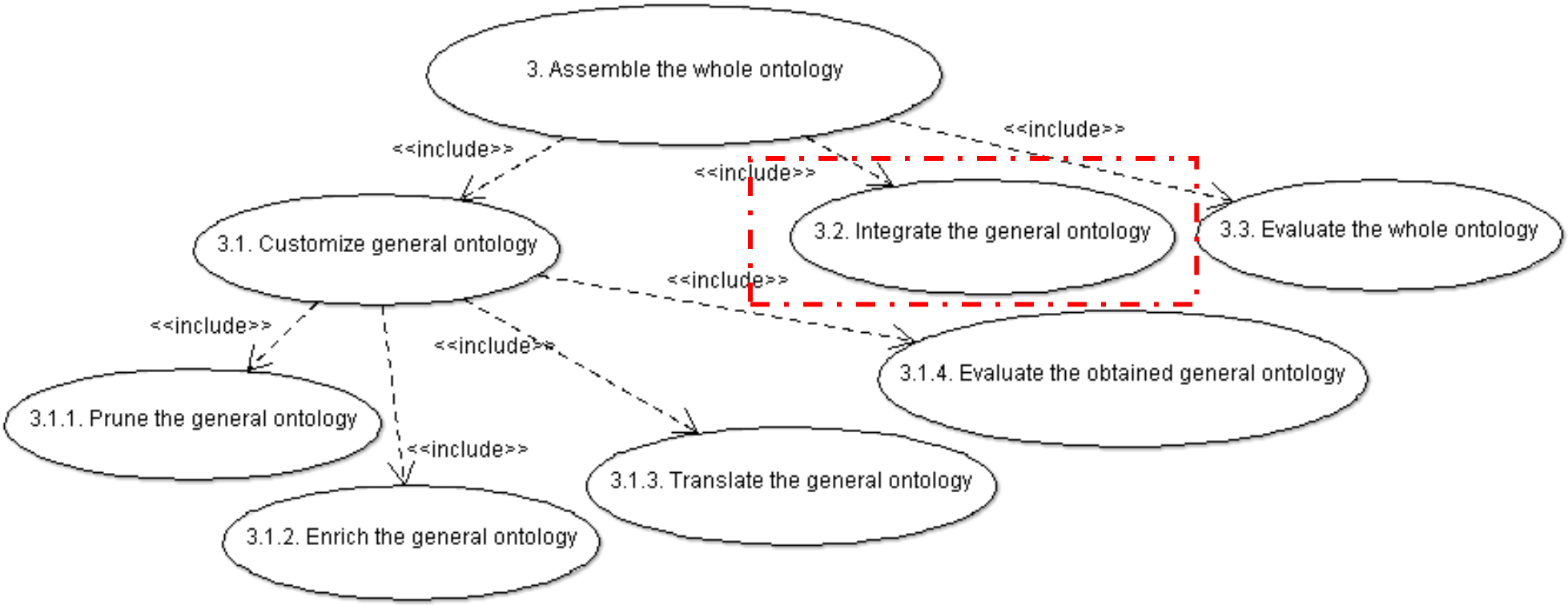
We added (a) transitivity to the part and `properPart` object properties; (b) reflexivity to part; (c) asymmetry to `properPart`; and (d) antisymmetry to part.

Evaluating

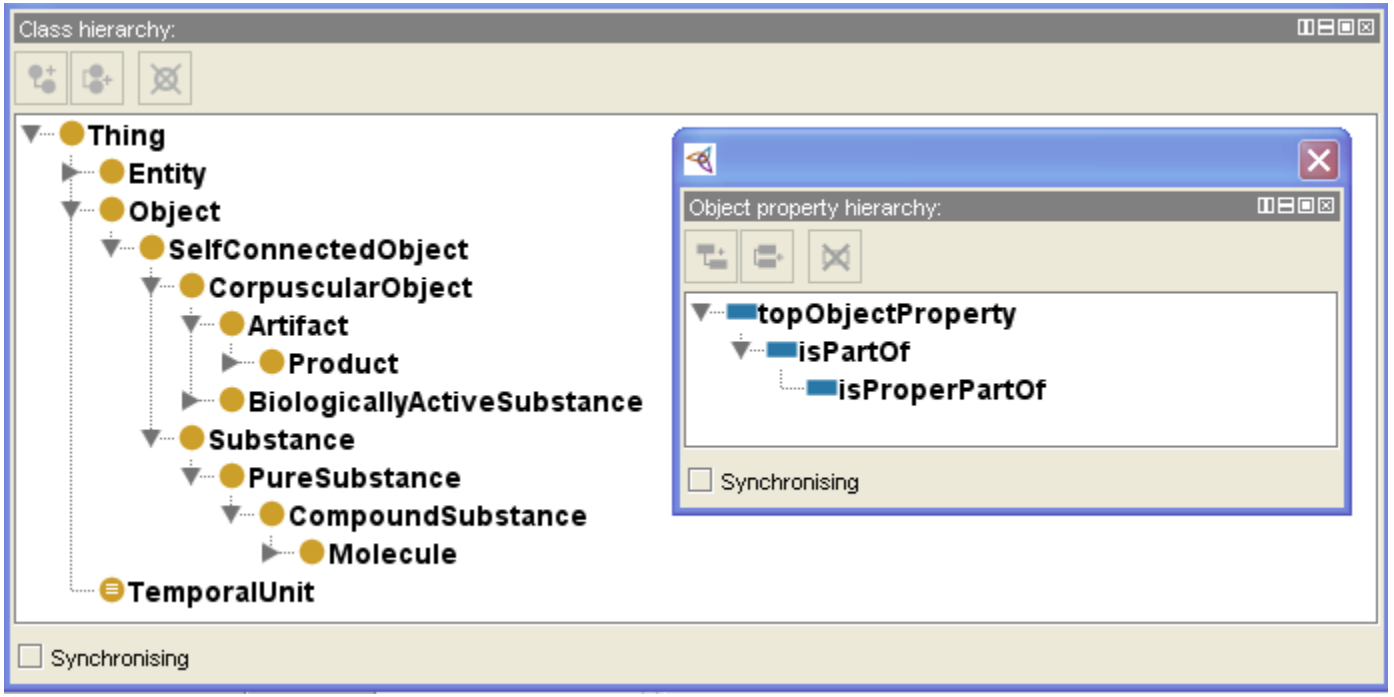


We checked that the resulting ontology has the expected attributes

STUDY CASE. INTEGRATE THE GENERAL ONTOLOGY



STUDY CASE. INTEGRATING THE ONTOLOGY TO BE REUSED



STUDY CASE. INTEGRATING THE ONTOLOGY TO BE REUSED

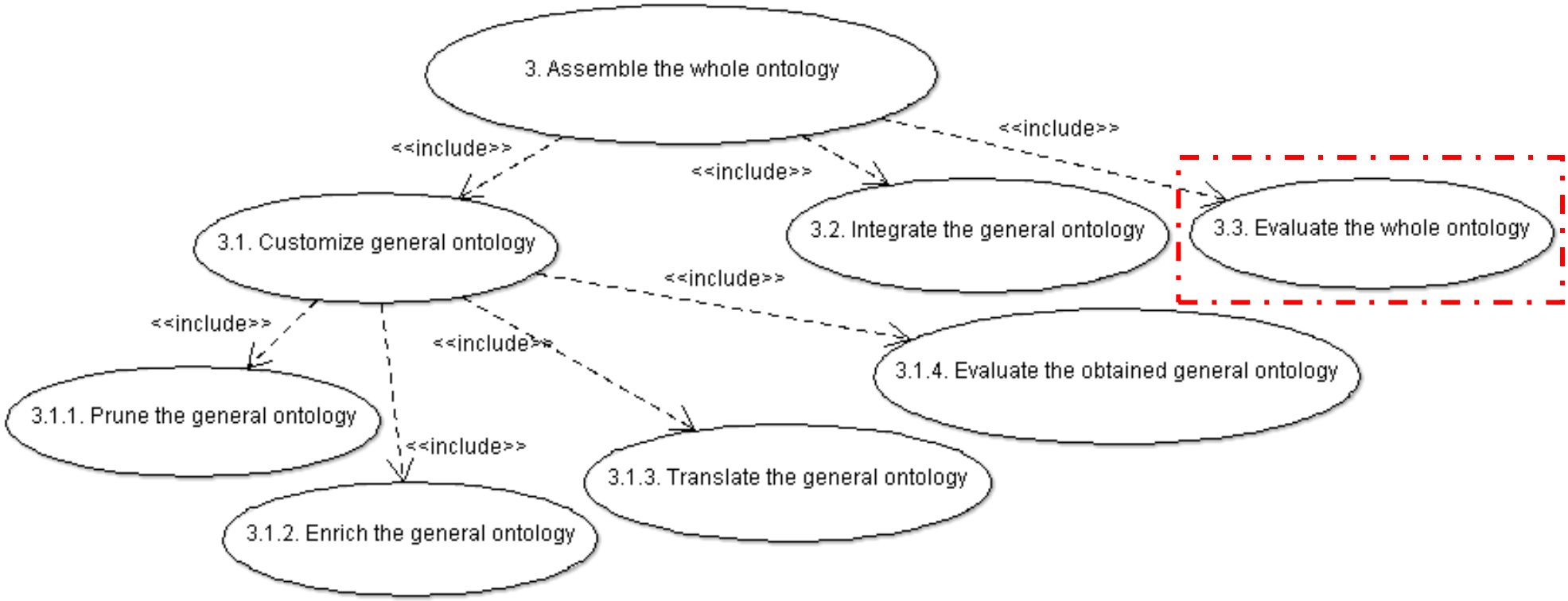
Links between terms of the reused ontology and the ontology to be developed should be established.

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

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

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

STUDY CASE. EVALUATE THE GENERAL ONTOLOGY



STUDY CASE. 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
		---------- 	

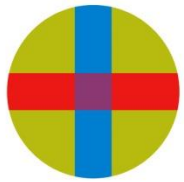
Which is the composition of Frenadol®?	# CQ2
	SELECT ?X
	WHERE
	{
	?X ub:isProperPartOf
	ub:FrenadolSubstance .
	}
		---------- 	
		|X |
		==========
		|Dextrometorphan
		|CitrateOfChlorpheniramine
		|Caffeine
		|Paracetamol
		---------- 	

STUDY CASE. 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 |
		--------------- 	

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



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