

TWO-LAYERED APPROACH TO KNOWLEDGE REPRESENTATION USING CONCEPTUAL MAPS AND DESCRIPTION LOGICS

Gomez-Gauchia, Diaz-Agudo and Gonzalez-Calero

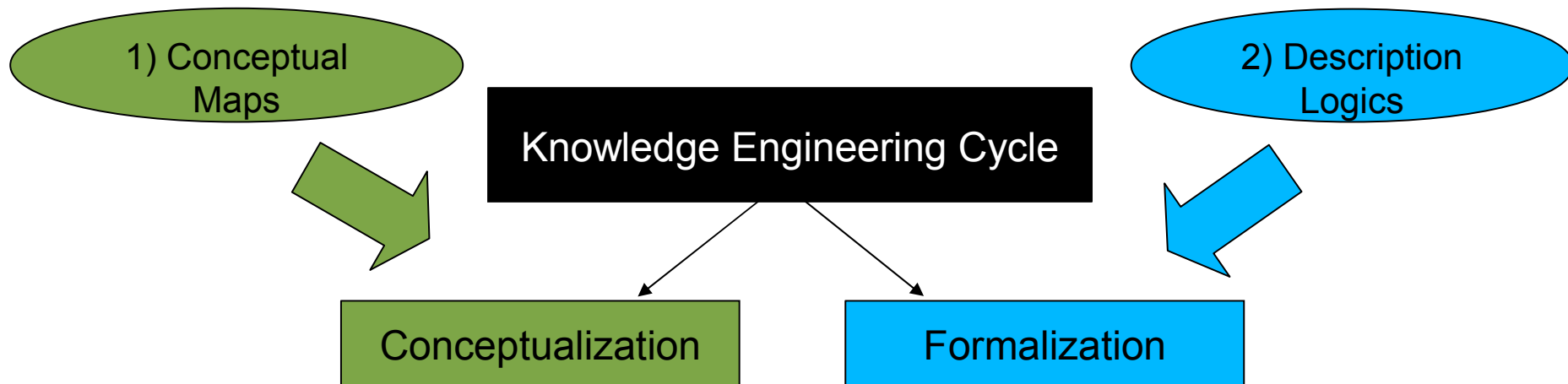
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overview | **paper outline**

1. Introduction
2. Lightweight ontology methodology
3. Ontology representation using CMAPS
4. Ontology representation using Description Logic
5. Ontology transformation from CMAPS into DL
6. Case study results
7. Conclusions and further work

1. introduction | **problem addressed**

- **General problem:** Knowledge Acquisition Bottleneck
- **General solution:** Case Based Reasoning
- **Specific problem:** Description Logics (DL) Formalization is hard
- **Specific Solution:** Two-layered approach to break formalization blockage
 - A graphical layer based on **Conceptual** Maps
 - A **Formal** layer based on Description Logics



1. introduction | problem addressed

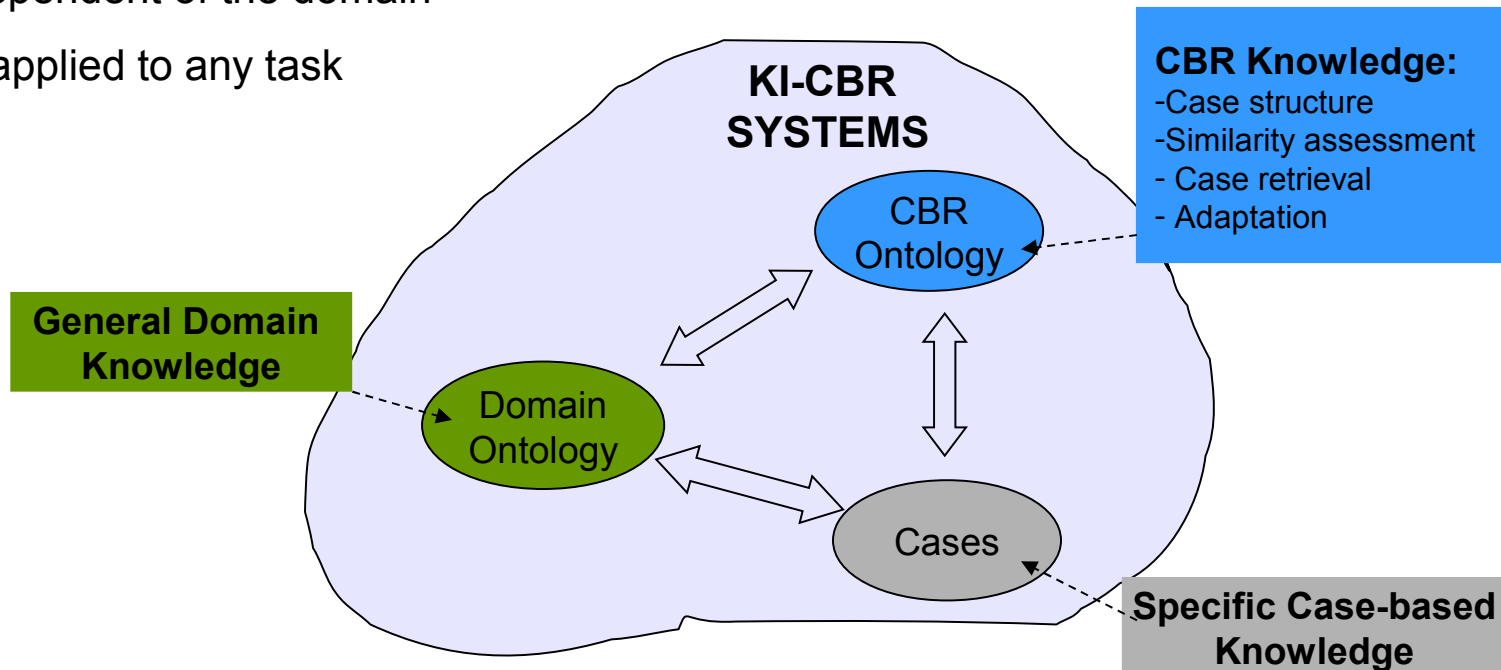
Graphical representations have been proposed to reduce the conceptualization problem, and to facilitate knowledge capture and representation, most notably, Conceptual Maps.

References:

- CBR tools for aerospace design domain, by Leake and Wilson 2002.
- *Rapid Knowledge Formation (RKF)*. <http://www.rl.af.mil/tech/programs/rkf/>

The **main contribution** is a Knowledge Intensive CBR (KI-CBR) framework:

- It is independent of the domain
- Maybe applied to any task



2. Methodology | **lightweight ontologies**

Problems to build ontologies based on recommended **methodologies** and **guidelines**:

1. Lack of understanding of domain terms and lack of experts
2. Formalization difficulties experienced by non computer experts (DL experts)
3. Structure and material support to guide the process

Proposed solutions based on theoretical paradigms from other research areas:

1. Information Retrieval and Document Structure processing techniques
2. To support human communication through conceptual structures (CMAPS)
3. To build up the domain ontology in an incremental manner using modeling strategies:
 - Top-down
 - Bottom-up
 - Middle-out

2. Methodology | lightweight ontologies

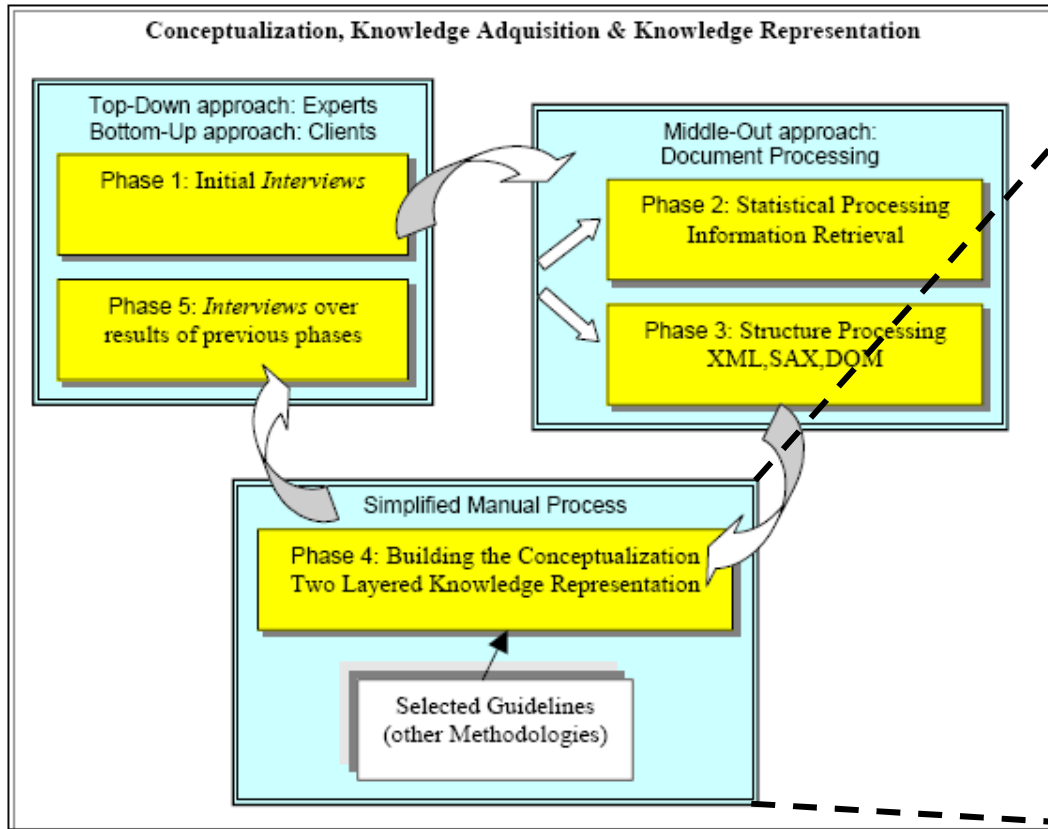
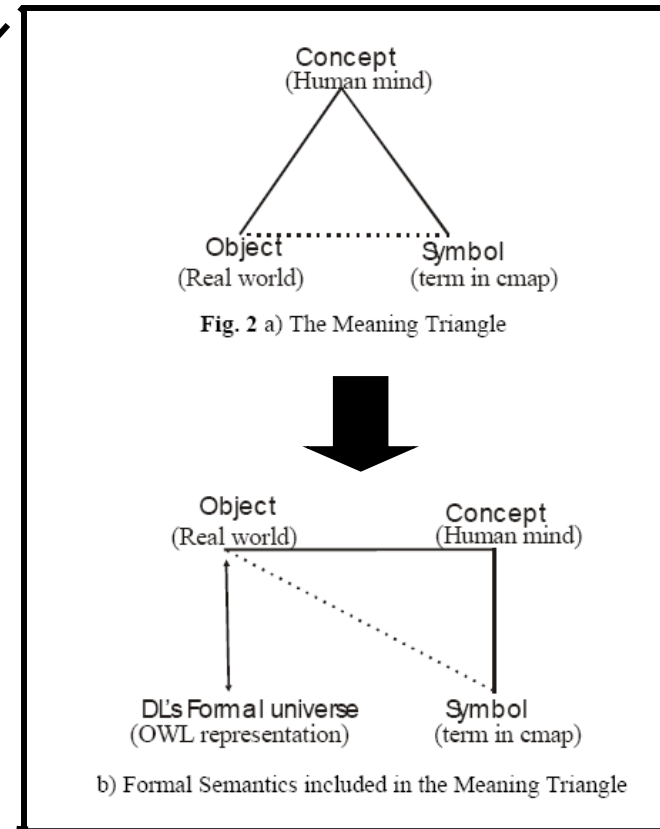


Fig. 1: Lightweight Ontology Methodology summary: Refinement Cycle



b) Formal Semantics included in the Meaning Triangle

3. ontology representation | conceptual maps

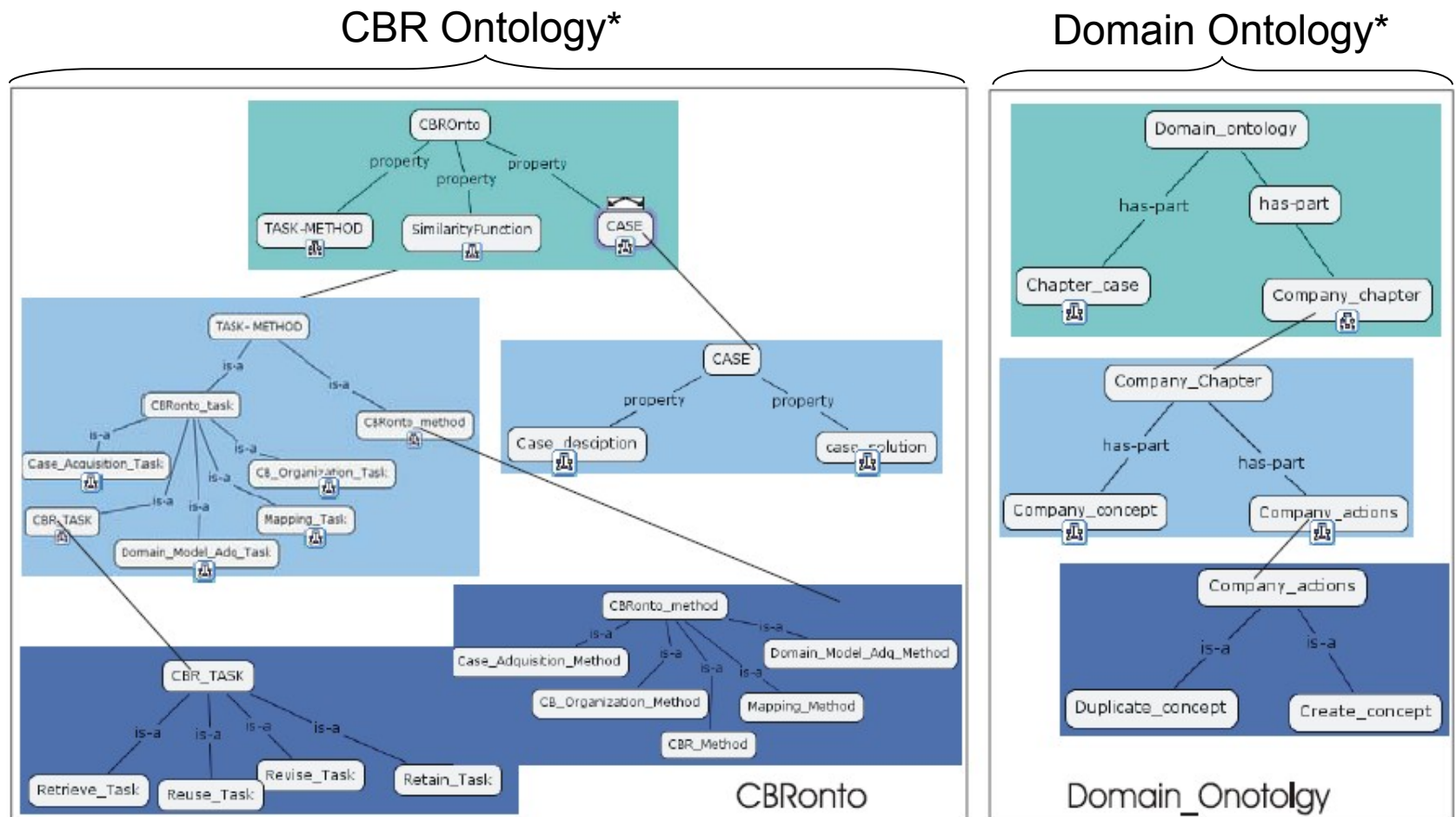


Fig 3. Ontologies of the Methodology applied to a KI-CBR system of Help-Desk

CmapTools: <http://cmap.ihmc.us/conceptmap.html>

3. ontology representation | conceptual maps

CBR Ontology*

Domain Ontology*

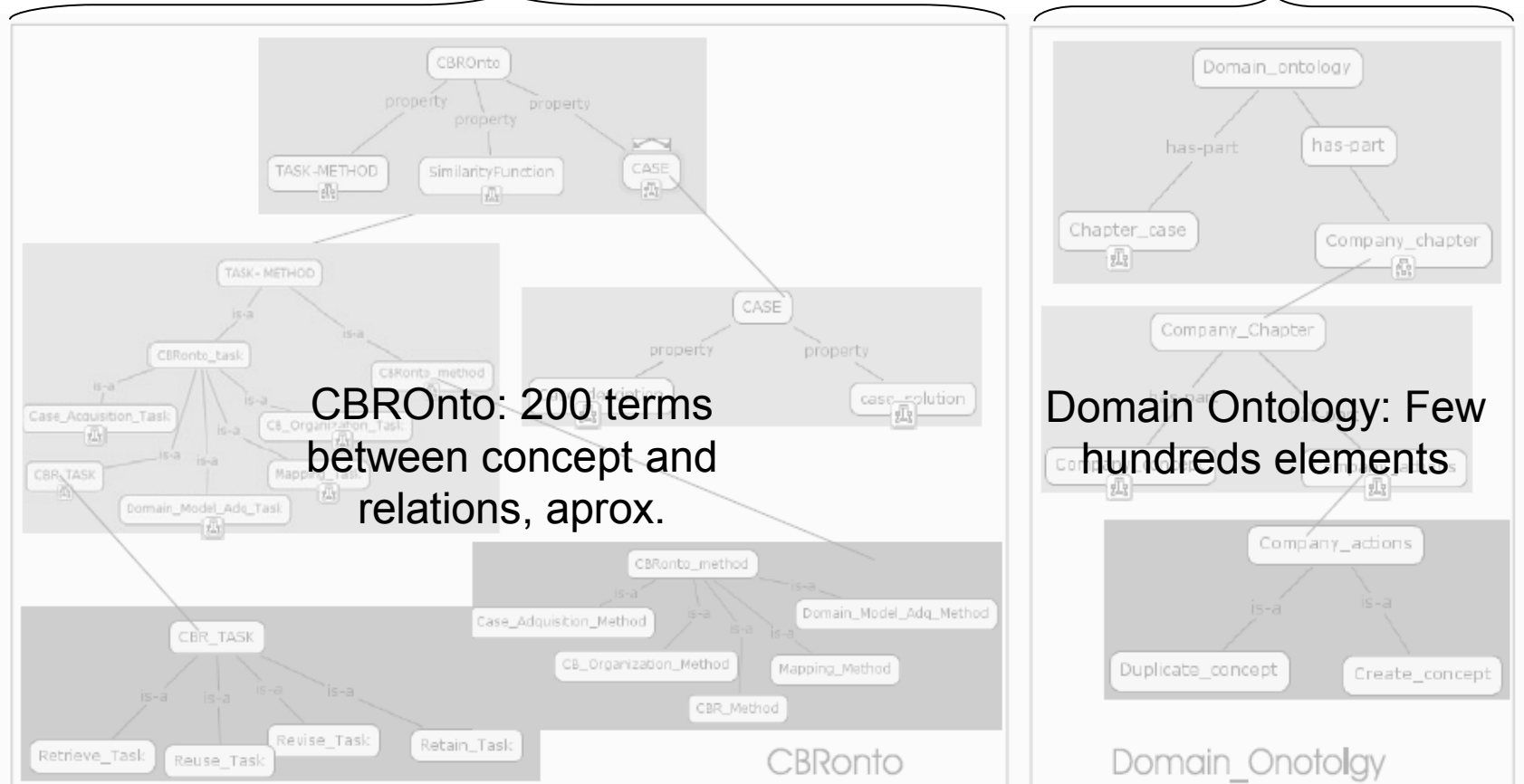


Fig 3. Ontologies of the Methodology applied to a KI-CBR system of Help-Desk

CmapTools: <http://cmap.ihmc.us/conceptmap.html>

4. ontology representation | description logics

Representational **formalism** used to represent about concept representations.

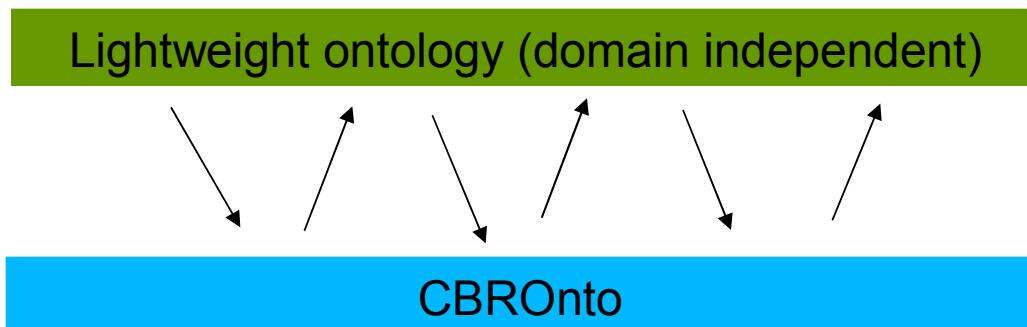
Provides **logical basis** to Frame-based systems, Semantic Networks, etc.

Provides efficient mechanisms for **reasoning** (inference):

- **Subsumption**: when a concept is more general than other (classification).
- **Instance recognition**: concepts that an individual satisfies and the relations a tuple satisfies.
- **Contradiction detection**: for both descriptions and assertions about individuals.

DLs as extension of First-order predicate calculus:

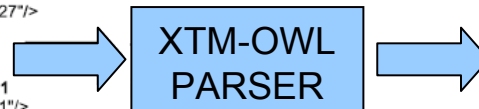
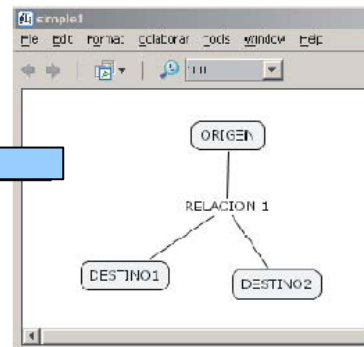
- **TBox** (Terminological Box) ←
- **ABox** (Assertional Box)



5. transformation | from CMAPS to DLs

```

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xmlns="http://www.topicmaps.org/xtm/1.0/" ... >
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    <instanceOf>
      <subjectIndicatorRef ... xlink:href="http://cmap.coginst.uwf.edu/#concept"/>
    </instanceOf>
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    </baseName>
  </topic>
  ...
  <baseName> <baseNameString>other 'concept' topic</baseNameString>
  </baseName>
  ...
  <baseName> <baseNameString><![CDATA[ORIGEN]]></baseNameString>
  </baseName>
  ...
  <xlink:href="http://cmap.coginst.uwf.edu/#linkingPhrase"/>
  a 'linkingPhrase' topic
  <baseNameString><![CDATA[RELACION ]]></baseNameString>
  ...
</association id="assoc_1082994122812_680129440_444">
  ...
  <xlink:href="http://cmap.coginst.uwf.edu/#incoming"/>
  → this number is ORIGEN
  <topicRef xlink:type="simple" xlink:href="#1082994112359_1142850275_427"/>
  ...
  <subjectIndicatorRef xlink:type="simple"
  xlink:href="http://cmap.coginst.uwf.edu/#outgoing"/>
  → this number is DESTINO 1
  <topicRef xlink:type="simple" xlink:href="#1082994122796_538001187_441"/>
  ...
  <xlink:href="http://cmap.coginst.uwf.edu/#outgoing"/>
  → this number is DESTINO 2
  <topicRef xlink:type="simple" xlink:href="#1082994142328_1528135851_471"/>
  ...
  
```



```

<owl:Class rdf:ID="DESTINO1"/>
<owl:Class rdf:ID="ORIGEN1">
  <rdf:subClassOf>
    <owl:Restriction>
      <owl:someValuesFrom>
        <owl:Class rdf:ID="DESTINO2"/>
      </owl:someValuesFrom>
      <owl:onProperty>
        <owl:ObjectProperty rdf:ID="RELACION1"/>
      </owl:onProperty>
    </owl:Restriction>
  </rdf:subClassOf>
  <rdf:subClassOf>
    <owl:Restriction>
      <owl:someValuesFrom rdf:resource="#DESTINO1"/>
      <owl:onProperty rdf:resource="#RELACION1"/>
    </owl:Restriction>
  </rdf:subClassOf>
</owl:Class>
  
```

Fig 4. A conceptual map: graphical representation in CmapTools and in XTM format

Fig. 5. The example transformed into OWL

Offline update: loading existing maps

Online updates:

- Terminological updates (user defined using CMAPS)
- Assertive updates (system defined in the DL layer)

Inferences made by RACER (only unary and binary relationships)

6. results | case study

- GoldenSoft: Help-desk system for a management software.
- Supports phone calls with questions regarding the management software.
- 10 technicians trained during 1 year.
- 200 hundreds of calls with complex problems of several types.
- Some questions take hours to solve.
- Knowledge elucidation methodology has been implemented, but 2 hard duties remain to experts:
 - Check and refine the domain general knowledge that is automatically extracted from company documentation.
 - Integrate domain terminology within CBR Onto in order to allow reusability of CBROnto methods.
- Informal comparison between conceptual modeling using Protégé (ontologies) and CMAPS shows that experts had a better experience using CMAPS (10 experts poll)

conclusions | discussion

- The paper doesn't explain how cases are represented and processed.
- Is the translation from CMAPS into DL so straightforward?
- How does the refined DL model update the CMAP? (bi-directional?)
- Rather than discuss representation in detail the paper discusses the important problem of knowledge elucidation, capture and conceptualization (knowledge bottleneck).
- CMAPS works as interface for further refinement. In this sense it emphasizes human cognition and collaboration.

Thanks