A Pattern-based Framework for Representation of Uncertainty in Ontologies

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Abstract. We present a novel approach to representing uncertain information in ontologies based on design patterns. We provide a brief description of our approach, present its use in case of fuzzy information and probabilistic information, and describe the possibility to model multiple types of uncertainty in a single ontology. We also shortly present an appropriate fuzzy reasoning tool and define a complex ontology architecture for well-founded handling of uncertain information.

Motivation for our research is the CARETAKER project[4] which comprises advanced approaches to recognition of multimedia data, which led us to problems of representing uncertain information.

Although fuzziness isn't, exactly said, type of uncertainty, we will in this example consider representing fuzzy information in the form of facts, i.e. A-Box from description logic (DL) point of view. The key principle of our approach to representing fuzzy information is the *separation* of crisp ontology from fuzzy information ontology. We allow the fuzzy ontology to be OWL Full and only suppose that the base ontology is OWL DL compliant. Regular OWL DL crisp reasoning tools can be applied to the base ontology, fuzzy reasoning tools (i.e. FiRE[5]) to fuzzy ontology.

Instantiation axioms in Fuzzy OWL [1] are assertions of form $\langle a : C \bowtie n \rangle$ – facts saying that individual a belongs to class C, n is level of certainty $(0, 1)$ and $\bowtie$ is one of $\{\leq, <, \geq, >\}$. We introduce a few constructs that enable us to model such axioms with uncertainty by ontology patterns. For each crisp axiom of base ontology we create a new individual belonging to class fuzzy-instantiation, which will have several properties attaching it to that crisp axiom in base ontology and implementing uncertainty. Properties fi-instance and fi-class characterize the membership of an individual person-1 to class problem-person. Property f-type defines the type of uncertainty relation ($\bowtie$) and datatype property f-value defines the level of uncertainty n (Fig. 1, individuals are grayed and classes are bright).

[4] http://www.ist-caretaker.org/
[5] http://www.image.ece.ntua.gr/∼nsimou

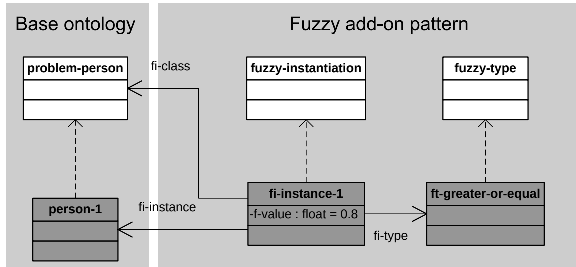

Fig. 1. Instantiation pattern

One of major advantages of our modeling approach is that it enables us to model various kinds of uncertainty in same ontology at the same time. Using approach described above we can define well-founded architecture of ontology that fully supports handling uncertainty – Uncertainty Modeling Framework (UMF): crisp ontology is aligned to foundational ontology (i.e. DOLCE) while fuzzy and i.e. probabilistic ontology are based on appropriate patterns of UMF. Such architecture is modularized, so these parts of ontology are separated to independent modules. On top of these ontologies there can be number of different specialized reasoners operating (Fig. 2).

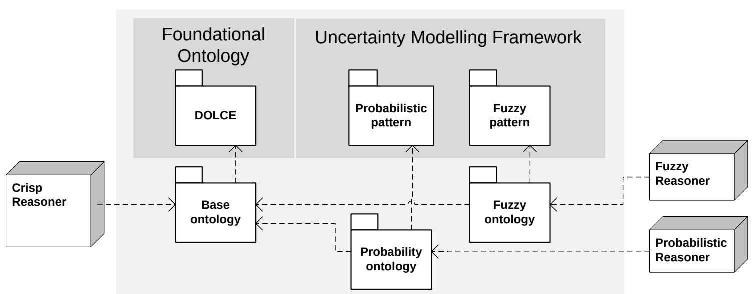

Fig. 2. Ontology architecture supporting reasoning with uncertainty.

More information can be found in full paper draft[6]. M. Vacura, V. Svátek and N. Simou are supported by the EC under FP6, project K-Space (no.: FP6-027026), and first two also by the Czech IGA VSE grant no.12/06. P. Smrž is supported by the EU FP6 project CARETAKER (no.: FP6-027231).

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[6] `http://keg.vse.cz/_papers/2007/framew.pdf`