Reasoning Approaches for Nominal Schemas[*]

Cong Wang, Adila Krisnadhi, David Carral Martínez and Pascal Hitzler

Kno.e.sis Center, Wright State University, Dayton OH 45435, USA

Abstract. Nominal schemas are a new DL constructor which can be used like "variable nominal classes" within axioms. This feature allows DL languages to express arbitrary *DL-safe rules* in their native syntax. In this paper we summarize several reasoning approaches recently devised to reason over nominal schemas. Although we have made some progress, there are still some interesting challenges yet to be solved.

1 Introduction

Nominal schemas are a new constructor that enhances the expressivity of the DL paradigm. Extended with nominal schemas, the DLs fragments can encompass *DL-safe SWRL*, arbitrary *Datalog rules* and even some non-monotonic rules [1] expressivity. Although the inclusion of this new constructor does not worsen the complexities of the DL languages, the development of practical reasoning algorithms for nominal schemas is a challenging task.

Many traditional algorithms require normalization of DL axioms, but nominal schemas can be used to represent arbitrary complex rules and hence prevent us from achieving normal forms. A naive *full-grounding* algorithm can solve this issue by replacing nominal schemas in an axiom with all the possible combinations of named individuals contained in a given ontology. Although this approach is complete, it usually results in a huge increase of the number of axioms making reasoning unpractical. We have therefore started to study some "smart" approaches that could potentially limit the grounding of nominal schemas reducing the overhead of full grounding.

2 New Algorithms

Tableau Based Algorithms. We have defined a modification [2] which extends standard tableau algorithms with grounding rules in such a way that grounding can be delayed until required. For example, considering $C \sqsubseteq \exists R.\exists S.\{z\}$, we can delay grounding of z after applying $\exists$-*rule* on $\exists R.\exists S.\{z\}$. While this new algorithm provides a more flexible way of grounding, it needs good heuristics that could speed up the grounding in practice (See details in [2]).

Resolution Based Algorithms. As opposed to the previous approach, the resolution calculus for algorithmization, where grounding is handled on the fly via unification, can potentially reduce the amount of groundings. The proof of termination usually relies on the saturation on limited types of clauses, but in many cases nominal schemas can lead to many complicated clauses. The resolution based algorithm successfully addresses this problem problem by using a lifting lemma showing resolution on nominal schema axioms takes fewer resolution steps than performing resolution on fully grounded knowledge bases. (See details in [4]). But, it is believed that resolution procedure is hardly optimized to reduce the number of many irrelevant clauses produced. Moreover, we have no clue to handle with role chain.

Hypertableau Based Algorithms. The tableau and resolution calculi both may not be efficient enough to deal with nominal schemas. The *Hypertableau*, combining the mechanism of the tableau and resolution calculi, can reduce nondeterminism and the size of the constructed models. It takes clauses into which nominal schemas can be easily translated and all such clauses are *Horn-like* such that nondeterminism can be reduced. However, the blocking condition and $\exists$-*rule* still have to be carefully modified in order to ensure termination.

More. One may also consider the approach in [3] by translating DLs axioms into a set of *datalog* rules. The remaining challenge still lies on the normalization issue. Consider such an axiom with complex concept at right head, $\exists R.\{z\} \sqsubseteq \exists S.(\exists T.\{z\} \sqcap C)$. It is not straightforward to see how to translate it.

3   Conclusions

We show an interesting and challenging reasoning problem in this paper. Our previous attempts are not fully satisfying, but we foresee some more promising approaches. One can proceed in addressing the problem by borrowing some thoughts.

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