Università degli Studi della Calabria

Dipartimento di Matematica

Dottorato di Ricerca in Matematica ed Informatica

XVI Ciclo

Tesi di Dottorato

Disjunctive Logic Programming: Efficient Evaluation and Language Extensions

Simona Perri

Tutor
Prof. Nicola Leone

Coordinatore
Prof. Annamaria Canino

Anno Accademico 2003 - 2004

Abstract

Disjunctive Logic Programming (DLP) is an advanced formalism for Knowledge Representation and Reasoning (KRR). DLP is very expressive in a precise mathematical sense: it allows to express every property of finite structures that is decidable in the complexity class Σ_2^P (NP^{NP}). However, the high expressiveness of Disjunctive Logic Programming comes at the price of a high computational cost. For 15 years the research on DLP has been carried out only on the theoretical side, because the hardness of the evaluation of DLP programs has discouraged the implementation of DLP engines for quite some time.

Only recently the efficient and solid implementation of a knowledge base system which efficiently support Disjunctive Logic Programming, named DLV, allowed to use DLP for solving real-world problems in a number of application areas, including planning, scheduling, automatic correction of census data, as well as for complex data manipulations [28, 98, 42]. However, practical applications in many emerging areas such as Knowledge Management or Information Integration, require even higher performances. Therefore, the design and the implementation of suitable optimization techniques are fundamental for the efficiency of DLV.

Moreover, despite the high expressive power of DLP, there are some kinds of problems that cannot be encoded in a natural way and then the resulting programs are often complex and tricky.

In this thesis we focus on these issues; from the one hand we propose new techniques aiming at improving the efficiency of DLV. On the other hand, we propose new extensions of Disjunctive Logic Programming for enhancing its knowledge modelling abilities. In short, the main contribution of the thesis is the following:

1. We study DLP, analyze its complexity and its exploitation for knowledge representation and reasoning.

2. We design a new method, based on join-optimization techniques, for reducing the instantiation time of DLP programs. We implement the proposed method in the DLV system and perform an experimental analysis.

3. We design a new structure based backjumping method for reducing both the size and the time of the instantiation. We implement the proposed method in DLV and carry out an experimental activity.

4. We define an extension of DLP by Parametric Connectives. We formally specify the semantics of the new language, named $DLP^{\vee,\wedge}$ and we show

the utility of the new constructs on relevant knowledge-based problems. We address some implementation issues, providing the design of an extension of the DLV system to support $\text{DLP}^{\vee,\wedge}$.

5. We formally define a new framework for abduction with penalization from logic programs. We analyze the computational complexity of the main problems arising in this context. Finally, we implement a system supporting the proposed abductive framework on top of the DLV engine. To this end, we design a translation from abduction problems with penalties into logic programs with weak constraints. We prove that this approach is sound and complete.