Reasoning with Type Definitions

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Abstract. This article presents an extension of the basic model of conceptual graphs: the introduction of type definitions. We choose to consider definitions as sufficient and necessary conditions to belong to a type. We extend the specialization/generalization relation on conceptual graphs to take advantage of these definitions. Type contractions and type expansions are clearly defined. We establish the correspondence with projection by use of the atomic form of conceptual graphs. Finally, we give a logical interpretation of type definitions and prove that the correspondence between logical deduction and generalization relation is maintained.

Keywords: type definitions, contraction, expansion, atomic form, projection, logical interpretation.

1 Introduction

The aim of knowledge representation is to provide formal model which allow to modelize different kinds of knowledge and allow to reason with this knowledge. In conceptual graphs (CGs), the knowledge is split into several levels. The terminological level defines the conceptual vocabulary. It contains the concept type lattice and the relation type poset. These two taxonomies are simply composed of strings, representing concept types or relation types, which are ordered by a specific/generic relation. At the assertional level, one describes some facts by CGs constructed with the conceptual vocabulary.

However, we often dispose of general knowledge which is relevant to terminological level but one can’t represent it with a simple specific/generic relation. J. Sowa proposes the formalism of abstractions to answer this need. In this paper, we study a kind of complex terminological knowledge: the type definition.

We start from the basic model of CGs, introduced by J. Sowa in [Sow84] and clarified by M. Chein and M.L. Mugnier in [CM92, MC96], and extend it to take into account type definitions when we are reasoning at assertional level. This extension includes contraction and expansion operations in the specialization rules. The connection with the projection is established once again. After giving a logical interpretation for definition, one demonstrates that the specialization relation always corresponds to a complete and sound set of inference rules.
In section 2, we present the different semantics that we can give to type definitions and we remind the type definition syntax. Then we choose to consider a definition as a set of sufficient and necessary conditions for belonging to a type. Section 3 introduces the four new specialization rules allowing to manipulate the type definitions at assertional level: contraction and expansion of concept types or relation types. Then we show in section 4 how projection allows to compute the new specialization relation. The section 5 is devoted to logical interpretation of type definitions and contraction/expansion rules.

2 Type definition formalism

In the basic model of CGs, the meaning of a type is given by position which hold into the taxonomy of types. The specific/generic relation is thus the only definitional mechanism. Such a representation of meaning for concept types and concept relations is very poor. Often one has some generic information on types which are not expressible by this single mechanism. The mechanism of type definition address this problem by associating a formal description to a type. This description is constructed with atomic types (a type without description) and already defined types. The semantics given to the type/description association determine the reasoning technics to use with this form of knowledge representation.

In this work, we consider that descriptions represent a set of characteristics, properties, attributes which can be shared by objects of the domain of representation. A description is thus the intensional representation of a set of objects. It remains to define the semantics given to the link between a type and its description. In general, two semantics are used:

- the description represents a set of sufficient and necessary conditions to belong to its type. Any object recognized by the description must belong to the type and any instance of type owns the attributes of the description. The description is thus the intensional representation of type. These semantics are given to defined concepts in the KL-ONE derived systems [WS92]. Such semantics are called definition;
- the description only represents a set of necessary conditions to belong to its type. These are semantics that is used for natural kinds. In KL-ONE systems, they are given to primitive concepts. These semantics are sometimes called partial definition.

In CGs, the descriptions are represented by abstractions (cf. [Sow84] section 3.6). They are conceptual graphs which one or several generic concepts are considered as formal parameters. In the following, we study description mechanism to do some definitions and not to do partial definitions.

Definition 1 A concept type definition asserts an equivalence between a concept type and a monadic abstraction. We denote \( t_c(x) \overset{\text{def}}{\leftrightarrow} D(x) \) the definition of type \( t_c \) with \( x \) the variable of formal parameter. The formal parameter concept vertex