CHAPTER 43

QUERY ANSWERING IN DISTRIBUTED DESCRIPTION LOGICS

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Abstract: This paper describes the notion of query answering in a distributed knowledge based system, and gives methods for computing these answers in certain cases. More precisely, given a distributed system (DS) of ontologies and ontology mappings (or bridge rules) written in Distributed Description Logics (DDL), distributed answers are defined for queries written in terms of one particular ontology. These answers may contain individuals from different ABoxes. To compute these answers, the paper provides an algorithm that reduce the problem of distributed query answering to local query answering. This algorithm is proved correct but not complete in the general case.

1. INTRODUCTION

The emergence of the Semantic Web has focused the attention on developing systems in which knowledge can be shared in a distributed environment. Besides, query answering in expressive knowledge base is a difficult task. Therefore, when knowledge description is separated into different knowledge bases, query answering becomes an even more tedious problem. The present paper investigates a new approach to the problem, where local knowledge bases (ontologies) may represent heterogeneous domains, but are related with directional mappings that express how one can interpret foreign knowledge from a given peer’s point of view. Queries are posed in terms of one local ontology (the target), and answers are given in the context of the target ontology, while taking advantage of the overall distributed knowledge. For such an approach, Distributed Description Logics (DDL [1]) is an appropriate knowledge representation language, but it has currently no supports for queries with variables. So, this paper defines the notion of distributed answers to a query. Then, to evaluate queries, we propose to reduce the problem of distributed...
query answering to a local query answering problem, assuming that there already exist local query evaluation algorithms (e.g., [2,3]).

Several peer-to-peer (P2P) data management systems have been proposed recently, which are divided into two main categories: centralized systems (e.g., [4]) and decentralized systems (e.g., [5,6,7]). [5] presents a relational P2P data management system, and the mappings between relational peer schemas are inclusion and equivalence statements of conjunctive queries. The Piazza system [8] is a P2P data management system that relies on a tree based data model: data in XML and XQuery-based mapping language for mediating between peers. PEPSINT [4] supports interoperability of both XML and RDF data sources, using a hybrid architecture with a super peer containing the global ontology. EDUTELLA [6] provides an RDF-based metadata infrastructure for P2P networks. [9,7] describe the SomeWhere semantic P2P data management system that promotes a small vision of the Semantic Web based on simple ontologies distributed at a large scale, and logical mappings between ontologies make possible the creation of a web of people.

Most of the existing systems are assumed to work with rather homogeneous data, and they might prove useless if different ontologies are developed for a different context of application. This is the particularity of our work: DDL can handle distributed knowledge where each ontology may provide different context, and mappings between domains are handled through the use of the so-called bridge-rules. Another peculiarity of our approach is that, even though the query is posed in terms of one particular local ontology, a single answer may contain individuals from several knowledge bases.

The paper is organized as follows: we present the syntax and the semantics of DDL in Section 2. Section 3 presents the syntax and the semantics of the query language that we consider. In Section 4, we prove a theorem that provides a guideline for a query evaluation procedure over DDL. The concluding remarks and further work are presented in Section 5.

2. DISTRIBUTED DESCRIPTION LOGICS

Our work is based on DDL [1]. DDL serves to describe a distributed knowledge base (DKB) composed of several local KBs (written in standard DL) and of “bridge rules” that serve to connect terms from different local KBs.

2.1. Ontology Language: DL

Syntax. Our local KBs, that we will refer to as ontologies, are written in Description Logics (DL). The basic elements in DL are concepts, roles and individuals. Concepts (class of individuals) and roles (relations between individuals) are either primitive (named concepts or roles) or complex (recursively defined with constructors and other concepts or roles). Individuals can only be described by a name. Constructors are given in Table 1.