Chapter 13
Ontology Query Languages for Ontology-Based Databases
A Survey

Stéphane Jean
LISI/ENSMA and University of Poitiers, France

Yamine Aït Ameur
LISI/ENSMA and University of Poitiers, France

Guy Pierra
LISI/ENSMA and University of Poitiers, France

ABSTRACT
Current databases and their associated languages allow a user to exploit data according to their logical model. Usually, there is a gap between this logical model and the actual concepts represented. As a consequence, exploiting, exchanging and integrating data stored in databases are difficult. To overcome these problems, several approaches have proposed to extend current databases with ontologies. We called Ontology-Based Databases (OBDB) such databases. However, current database languages such as SQL have not been designed to exploit ontologies. Thus, a new generation of languages we called ontology query languages has emerged. The goal of this chapter is to provide an up to date survey on ontology query languages. We survey languages coming from the Semantic Web community as well as those coming from the database community.

INTRODUCTION
Data warehouses are designed to aggregate data and allow decision makers to obtain accurate, complete and up to date information. In current data warehouses, queries are issued to the logical model of data, making direct use of the table and column information that describes the persistence structure. Usually, there is a gap between this logical model and the actual business concepts used by decision makers. As a consequence, users of data warehouses have to use existing documentation (e.g., data dictionaries) - if any and if not out of date – to discover the meaning of tables and columns. This makes using and querying a data warehouse problematic for all users that have not designed it.

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Defined by Gruber as “an explicit specification of a conceptualization”, ontologies have been proposed to explicit the semantics of data. They allow to describe, in a consensual way, the relevant concepts of a given application domain. Thus, the idea to describe a data warehouse with ontologies in order to make explicit the semantics of data stored has emerged (Xuan et al., 2006). This idea is concretized by introducing an ontological layer in a data warehouse. This layer can be used by decision makers to express queries using business concepts they are used to manipulate. However, existing query languages such as SQL or OQL have not been designed to exploit ontologies. For this purpose, a new generation of query languages, called ontology query languages, has emerged.

The goal of this chapter is to provide an up to date survey on the capabilities of existing ontology query languages to manage databases extended with ontologies we call ontology-based databases (OBDBs). Previous surveys on ontology query languages (Bailey et al. 2005; Haase et al. 2004) have focused on the capabilities of Semantic Web query languages to manage RDF-Schema ontologies and data whatever be the used storage system. In this chapter, we propose to complete these previous surveys by taking a database-oriented point of view on ontologies we take (Jean et al., 2007b; Fankam et al., 2008) to compare existing ontology query languages.

Definition and Classification of Domain Ontologies

Several definitions have been proposed for an ontology (Gruber, 1993; Guarino, 1998). In our work a domain ontology is “a formal and consensual dictionary of categories and properties of entities of a domain and the relationships that hold among them”. This definition emphasizes three criteria that distinguish ontologies from other models used in Computer Science. An ontology is:

1. formal: it is based on a logical axioms and may be processed by computers; so checking consistency and performing automatic reasoning are made possible;
2. consensual in a community, i.e. several members have agreed upon the concepts represented in the ontology;
3. has the capability to be referenced. A universally unique identifier can be used to define the semantic of a piece of data, whatever are the modeling schema of the ontology and the data model.

All ontologies are not similar. We distinguish the three following categories:

- Conceptual Canonical Ontologies (CCOs) provide concepts definitions
- Query Languages and database-oriented ontology query languages in section 4 and 5. Finally, section 6 concludes this comparison and introduces future work.

DOMAIN ONTOLOGIES AND THEIR APPLICATION TO DATABASE

In this section, we present the database-oriented point of view on ontologies we take (Jean et al., 2007b; Fankam et al., 2008) to compare existing ontology query languages.

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