A Knowledge-Based System for Generating Informative Responses to Indirect Database Queries

XU WU AND NICK CERCONE
Department of Computer Science, University of Regina, Regina, Saskatchewan, Canada S4S 0A2
TADAO ICHIKAWA
Information Systems Laboratory, Faculty of Engineering, Hiroshima University, 1-4-1 Kagamiyama, Higash-Hiroshima 724, Japan

Abstract. The objective of this study is to develop a knowledge-base framework for generating cooperative answers to indirect queries. An indirect query can be considered as a nonstandard database query in which a user did not specify explicitly the information request. In a cooperative query answering system, a user's indirect query should be answered with an informative response, either an affirmative response or a negative response, which is generated on the basis of the inference of the user's information request and the reformulation of the users' indirect query.

This paper presents methods for inferring users' intended actions, determining users' information requirements, and for automatically reformulating indirect queries into direct queries. The inference process is carried out on the basis of a user model, call user action model, as well as the query context. Two kinds of informative responses, i.e. affirmative responses and negative responses can be generated by a rule-based approach.

Keywords: informative responses, cooperative query system, knowledge-based query answering, indirect queries

1. Introduction

The Cooperative Query Answering (CQA) problem has been explored for the development of intelligent database query answering systems. The difference between the cooperative query answering systems and the traditional database query answering systems is that the former can supply a user informative and useful answers through reasoning of the user's query plan, intention, interesting subjects, presuppositions, misconceptions, and so on (Gaasterland, Godfrey and Minker, 1992). These reasoning capability enable the cooperative query answering systems to response user's queries like human conversation (Webber, 1986; Kaplan, 1982; Kao, Cerone, and Luke, 1988; Cuppens and Demolombe, 1988). In the field of cooperative database query answering, three aspects have been mainly explored.

(1) Inference of a user's goal and plan from analysis of the user's database query: The inference process can be carried out by evaluating a rule-base which is composed of two kinds of rules, i.e., plan construction rules and plan inference rules, (Allen and Perrault, 1980), or by analyzing a hierarchical representation of plans and retrieval goals (McKeown, Wish, and Kevin, 1985). The principal strategies for plan recognition are plausible inference (Carberry, 1988; Litman and Allen, 1987; Sidner, 1985), parsing plan descriptions (Vilain, 1990), and resolution of ambiguous plans (Beek and Cohen, 1991).

(2) Detection of user's misconceptions and false presuppositions: When a novice user operates a database system, trouble arises from the difference in views about the objects modeled in the database, which are thus called false presuppositions (Kaplan, 1982). The false presuppositions contained in the queries sometimes cause failures in a
database retrieval, e.g., the direct result of database retrieval is NULL (Kao, Cerone, and Luke, 1988). User's presuppositions can be extracted directly from the user's query and can be then verified on the basis of the content of database (Kaplan, 1982) and the schema knowledge (Kao, Cerone, and Luke, 1988; Motro, 1986). On the other hand, user's misconceptions can be detected by evaluating the knowledge-base of Domain-Perspective (McCoy, 1989) and Integrity Constraints (Wu and Ichikawa, 1993; Gal and Minker, 1988).

(3) Formulation of associative answers by generalizing user's query: In contrast with the normal database answer that contains information directly asked by a user, an associative answer conveys the useful information which is not explicitly asked but conceptually related to the user's query. The key problem is how to determine a reasonable retrieval scope that satisfies the user's interest and intention. Many types of knowledge, i.e., semantic description of database (Motro, 1990), Retrieval Topics (Cuppens and Demolombe, 1988) and Subjects (Chu and Chen, 1992), are required for formulating an associative answer. From a user's query, a set of interesting objects can be inferred against the semantic description of the database. Within a DB-Pattern-KB framework that supporting both static grouping and dynamic linking of data and knowledge, a subject that is related to the user's interesting objects can be determined (Chu and Chen, 1992). According to the knowledge associated with each subject, the retrieval scope of the original query can be relaxed to including more information that would be useful to the user but not be explicitly asked in the original query.

The objective of our study is to develop a knowledge-based framework for formulating cooperative answers to indirect queries. An indirect query can be considered as a nonstandard database query in which the user did not specify explicitly the information request. In an interactive query answering environment, indirect query is an efficient means of refining unsuccessful query plan. Let's consider that a user have a retrieval goal G and tried to realize G through a query plan $P(G)$ consisting of the queries, $Q_1, Q_2, \ldots, Q_n$. In traditional database query answering systems, if the retrieval result obtained by performing the query plan $P(G)$ is undesirable, e.g., the result is 'null', the user should refine the query plan $P(G)$ and rewrite the queries of $P(G)$ for retrieving again. We call the specification for refining the unsuccessful query plan indirect query. Indirect query can be formulated in the same form with normal queries, but the information request is not specified. In the proposed framework, the system first infers user's retrieval goal from the user's previous queries and automatically rewrites the indirect query, and then generates information responses, including affirmative and negative responses, for the indirect query.

In this paper, the methods for the inference of users' information requirements from contextual queries and for generating informative responses on the basis of the inference will be described. In order to support the inference of a user's information requirement from the contextual queries, a user model, called user actions model has been developed in the system. The user actions model is constructed upon the semantic-network model S-Net (Wu and Ichikawa, 1992) which represents the semantic knowledge about the underlying database and user discourse domain. The user actions model consists of an action hierarchy, a set of Key Concepts tables and Key Attributes tables corresponding respectively to action nodes and case fillers represented in the action hierarchy. The construction of the action hierarchy is similar to that of the plan hierarchy (Kautz and Allen, 1986) and plan library (Beek and Cohen, 1991). But, the user action model proposed in this paper is different from the