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LACO: A location-aware cooperative query system for securely personalized services

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Abstract

Location-aware computing technology becomes promising for pervasive personalization services which run anytime, anywhere, and on any device. These services should be based on contextual queries that are provided in a fast and flexible manner. To do so, cooperative query answering may be useful to support query relaxation and to provide both approximate matches as well as exact matches. To facilitate query relaxation, a knowledge representation framework has been widely adopted which accommodates semantic relationships or distance metrics to represent similarities among data values. However, research shows few legacy cooperative query mechanisms that consider location-awareness. Hence, the purpose of this paper is to propose a securely personalized location-aware cooperative query that supports conceptual distance metric among data values, while considering privacy concerns around user context awareness. To show the feasibility of the methodology proposed in this paper, we have implemented a prototype system, LACO, in the area of site search in an actual large-scale shopping mall.

Keywords: Context-aware computing; Cooperative query; Abstraction hierarchy; Approximate query

1. Introduction

The purpose of context-aware computing is to make computing fit to peoples' ordinary lives and the activities they devote themselves to. With the help of context-aware computing, location-aware services aim at adapting responses to eventual context related changes in an unobtrusive manner. Unobtrusiveness is a key philosophy that discerns between legacy personalization systems and location-aware systems. Moreover, unobtrusiveness is tightly linked to privacy concerns, which is one of the main concerns of using location-aware systems, in that users frequently feel uncomfortable when the system compels them to input personal data for more services, or is even suspected of collecting and reusing users' data without the users' permission or approval. At a minimum, this requires an increased awareness and sensitivity to users' internal and external surroundings in order to be aware of the users' behavior intention.

To achieve this unobtrusiveness, several conditions must be met. First, the location-aware services should ask for only the minimum user input possible. Second, the location-aware system should resolve the user's privacy concerns around having to input personal data to enable further services. For example, let us suppose that the user may ask the system to recommend locations for a private meeting. In this case, since the user is neither willing nor able to query something personal, the user may simply ask "find western restaurant". However, since "western restaurant" in this context does not mean eating place but rather a space appropriate for a private meeting, the location-aware system should find a meeting place, rather than simply finding eating places as a result from querying "western restaurant". Third, a more realistic scenario allows users to submit vague queries rather than exact

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matches. Vague queries are common when the users do not actually know what they want. For example, a user who is traveling may query on "find a western restaurant". However, in this case, rather than specifically meaning a "western restaurant", the user is simply looking for somewhere to eat anything. In this case, the user would be more satisfied with a query result that shows "eating places", including western restaurants, in the user's vicinity. Thus, to address these unobtrusive queries in a location-aware system, accurately resolving vague queries in a way that takes both location-awareness and privacy concerns must be considered. However, legacy cooperative query algorithms fail to reflect how the changes of the user's current context affect concept distance computation. Moreover, current cooperative queries do not consider privacy concerns.

Hence, the purpose of this paper is to propose a securely personalized location-aware query methodology based on context data such as user's current location and schedule. The methodology resolves users' vague queries and personal preferences around privacy concerns by requesting only minimal input for query processing. To show the feasibility of the methodology proposed in this paper, a prototype system, LACO (Location-aware COoperative Query system), was implemented and actually used at COEX, one of the largest shopping malls in Korea.

The rest of this paper is organized as follows: Section 2 reviews the notion of the cooperative query answering. An example case, the COEX mall, is illustrated in Section 3. The background and structures of the Securely Personalized and Location-aware Metricized Knowledge Abstraction Query is proposed in Section 4. According to the characteristics of the methodology, LACO is discussed in Sections 5. Section 6 concludes the implications of CACO system with further research issues.

2. Literature review: cooperative query answering

Query processing based on conventional database systems do not possess any intelligence to cooperate with database users. Therefore, the users have to fully understand both the metadata and contents of the database. Even the users who are familiar to the database have to retry specific queries repeatedly with alternative values until the query result is satisfactory. Furthermore, the schema and semantics of databases are open too complex for the ordinary users to understand in their entirety to compose intended queries.

If a query processing system understands the schema and semantics of the database, it will be able to return informative responses beyond a query's requested answer set itself and greatly help the user write intended queries. To support such intelligent query processing, a number of cooperative query answering approaches (Babcock, Chaudhuri, & Das, 2003; Barg & Wong, 2000; Bosc, Motro, & Pasi, 2001; Gaasterland, 1997; Godfrey, 1997; Muslea, 2004; Siau, 1998; Wang, Li, & Shi, 2004) have been introduced, which provide a human-oriented interface to a database system. Typical steps for cooperative query answering include query analysis, query relaxation, and providing information relevant to or associated with the query. Query relaxation is performed by associating the values in the query condition to other related values on the basis of predefined semantic relationships between data values. Thus an appropriate knowledge representation framework is used, which is one of the most important factors that can affect overall performance and the characteristics of the cooperative query answering system.

The abstraction approach (Chu et al., 1996; Vrbsky & Liu, 1993) adopts the abstract representation of data values, and replaces the values by the abstract concepts to which they belong (Abiteboul & Duschka, 1998; Abiteboul, Benjelloun, & Milo, 2002). The abstraction representations form a data abstraction hierarchy where similar values are clustered by the abstract concepts and the individual abstract concepts are related to one another by a certain abstraction function or by abstraction similarities. The type abstraction hierarchy (Chu & Chen, 1994) introduced the notions of subsumption, composition, and abstraction, and offered an integrated view of the type hierarchy with a multi-level knowledge abstraction. The knowledge abstraction hierarchy (KAH) extended the type abstraction hierarchy, and it focused capturing value abstraction information with additional abstraction information that represented domain abstraction knowledge elicited from the underlying databases (Huh & Lee, 2001). However, these methods do not provide a quantitative similarity measure among data values, which is a common limitation of the methods employing the abstraction approach. Hence, with the abstraction approach, the users could not decide the importance of the results.

The semantic distance approach (Cuzzocrea & Matrangolo, 2004; Ichikawa & Hirakawa, 1986; Motro, 1988, 1996; Palpanas & Koudas, 2001) introduced the notion of distance, i.e., scalar values, to measure the strength of similarity between data values. Every pair of data values within the data set is supposed to have semantic distances (Motro, 1988), and thus this approach provides a straightforward and efficient method for query relaxation, and provides ranked results sorted by the semantic distance. The distances can be used as a measure to determine the rank of each answer, which helps users find useful information related to the retrieved answers. However, since the semantic distance does not consider the user's context, dynamic and personalized query processing is not doable.

3. Illustrative example

To explore and select an appropriate query method adequate to build up a large scaled system which is actually