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Evaluating the Effectiveness of a Collaborative Querying Environment

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Abstract. Collaborative querying seeks to help users formulate queries by sharing expert knowledge or other users' search experiences. In previous work, a collaborative query environment (CQE) was developed for a digital library. The system operates by clustering and recommending related queries to users using a hybrid query similarity identification approach. Users can explore the query clusters using a graph-based visualization system known as the Query Graph Visualizer (QGV). The purpose of this paper is to evaluate the CQE with goal of informing the usefulness and usability of such a system. Our results show that compared with traditional information retrieval systems, collaborative querying can lead to faster information seeking when users perform unspecified tasks.

1 Introduction

The study of information seeking behavior reveals that interaction and collaboration with other people is an important part in the process of information seeking and use [1, 6]. Given this idea, collaborative querying aims to assist users in formulating queries to meet their information needs by harnessing other users' expert knowledge or search experience [2]. A common approach in collaborative querying is to cluster similar queries issued by other users. Such queries are typically found in web user logs, which are then extracted and clustered to obtain recommended queries to users. In this way, there is an opportunity for a user to take advantage of previous queries used by previous users and use the appropriate ones to meet his/her information need.

In our previous work, a set of collaborative querying techniques was developed for a digital library [3, 4]. The system operates by clustering and recommending related queries to users using a hybrid query similarity identification approach. Users can explore the query clusters using a graph-based visualization system known as the Query Graph Visualizer (QGV). The QGV is designed as a Java applet and is an independent and reusable software component that can be incorporated into existing information systems to provide enhanced information retrieval services.

With the completion of the QGV, there is a need to assess its usefulness and usability with the goal of guiding future research in this area. A collaborative querying environment (CQE) was therefore developed by incorporating these collaborative querying techniques and the QGV into an existing OPAC system. A pilot study was then conducted with participants using the CQE to perform two categories of tasks. The remainder of this paper reports on the CQE, QGV, evaluation design and the results of this evaluation.

2 The Collaborative Querying Environment

Figure 1 shows the CQE that is built upon the OPAC system at Nanyang Technological University (NTU), Singapore. The system offers typical functions found in current information retrieval systems. Users submit their searches in the query area and view retrieved documents in the results list area. The results contain information about a document's title, author, call number and location of the information entity of physical format (e.g., the book is located in Library 2, Level B4). The details of each result item include this information together with the publisher and the subject heading, displayed in a separate popup window when selected from the results listing (Figure 2). In addition, the CQE shows recommended queries next to the search results list in HTML format. Users can click on the recommended queries to carry out further rounds of searches.

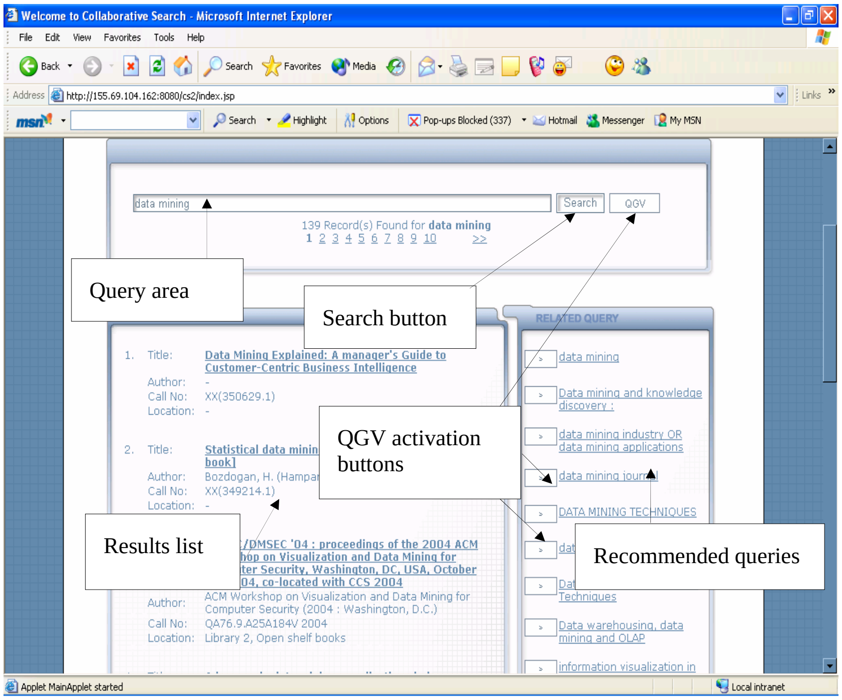

Fig. 1. The Collaborative Querying Environment

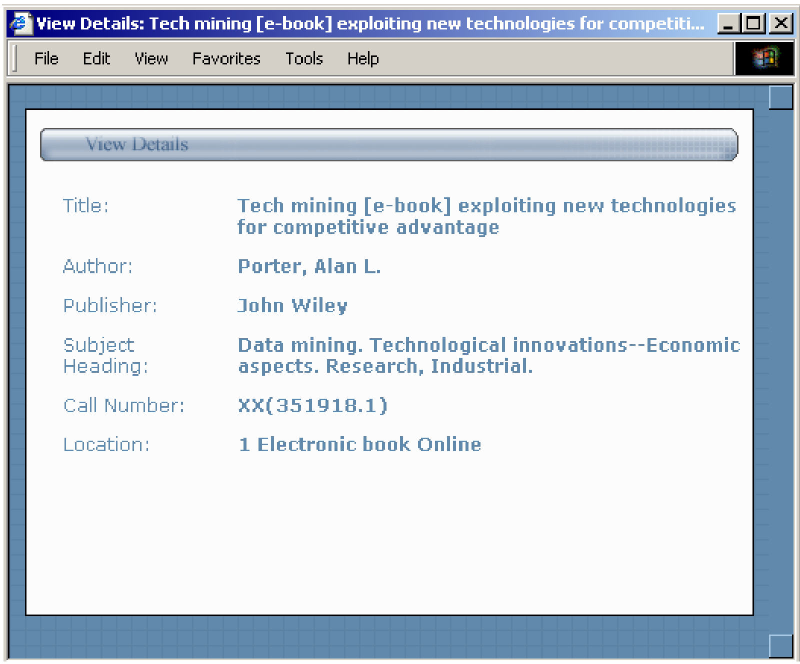

Fig. 2. Result Item Details

Further, users can trigger the QGV (Figure 3) to explore the relationship between the recommended queries in a graph format by clicking on the button next to the recommended queries in Figure 1. Each graph node represents a single query and edges between nodes show the relationship between two queries, with the value on the edge indicating the strength of the relationship. For example, 0.3 on the edge between the nodes "data mining" and "knowledge discovery" indicates that the similarity weight between these two nodes is 0.3. Figure 3 shows a network for the submitted query "data mining". This query is directly related to queries such as "predictive data mining" and "data warehousing, data mining and OLAP". The former in turn is related to "spss", a commonly used software tool in the field, indicating that "data mining" is also related to "spss". This approach therefore allows users to explore new query formulations that are diverse, sometimes unexpected, and potentially useful. More information on the QGV can be found in [6].

In a typical scenario of use, we consider a user who is interested in the field of data mining. He is a novice in this domain and would like to learn and explore related topics. When the user accesses the CQE, he first submits a query "data mining". A moment later, results of the query are displayed together with a list of queries related to "data mining" as recommendations (see Figure 1 for an example). After looking through the results list, the user feels that the results do not adequately meet his information need and he consults the list of recommended queries on the right column of the CQE interface. Due to a lack of domain knowledge in data mining, the user decides to peruse the relationships between the recommended queries before making use of them and thus decides to generate a query graph using "data mining" as the root node. The user therefore triggers the QGV which launches in a separate pop up window (see Figure 3 for an example).

While browsing the graph, the user becomes interested in the node "knowledge discovery". It is a new phrase to him but seems related to his search topic. Wanting to peruse the queries related to "knowledge discovery", he zooms into this node and examines queries related to it by using the graph navigation options of the QGV. After examining the graph carefully, the user is prepared to carry out another around of information retrieval by using the node "knowledge discovery". He thus right clicks on the node and chooses "Display result in a separate browser". The query "knowledge discovery" will be executed and the results displayed in the search page (see Figure 1 for example). The user may repeat this process of query reformulation and graph exploration until he finds the desired information.

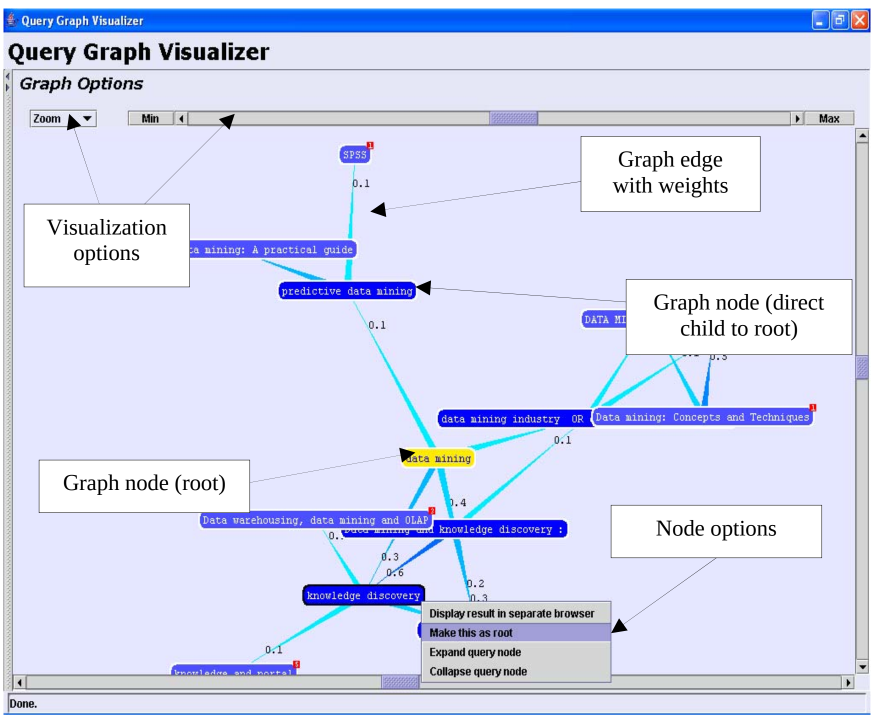

Fig. 3. The Query Graph Visualizer

A typical mode of interaction with the CQE can thus be summarized as follows:

- Formulate an initial query. The user will express the information need in a format understandable by the information retrieval system.
- Evaluate the results list: After the system returns the results from the initial query, the user will determine if the results contain the desired information. If not, a new query can be issued. Alternatively, the user can make use of the recommended queries generated by the CQE outlined in the next two steps.
- Examine the recommended queries in HTML format. The user will decide whether the recommended queries are appropriate in helping explore the domain of interest for query reformulation. If so, the recommended queries are activated by directly clicking on them.
- Explore query graph. The user might want to peruse the entire network belonging to a certain recommended query. He can thus trigger the QGV to examine the structure of the query graph and manipulate the visualization area by using options such as “zoom”, “rotate”, etc. The user can make use of a selected query by causing the QGV to post it to the OPAC. The results will then be displayed in the CQE.

3 Evaluation Design and Results

A pilot study was conducted on the CQE to assess its usefulness and usability for information retrieval. A two-by-two experiment design is described in this section with 4 users in each cell. One factor was the complexity of the tasks (clearly specified versus unclearly specified). The second factor was the type of information retrieval interface used (CQE versus the standard NTU OPAC). Figure 4 shows the interface of the NTU OPAC. The system offers standard query functions available in most OPAC systems including searching by keyword, subject, author, title, etc. The objectives of this study are:

- To determine for what kind of tasks can users benefit from the CQE.
- To assess the usability of the CQE.

3.1 Subjects

Sixteen students from NTU participated in this evaluation. Among the sixteen, six were undergraduate students and ten were graduate students. Six participants had an information studies background, five were from various areas in engineering and five were from communication studies. All participants confirmed they were experienced in using search engines.

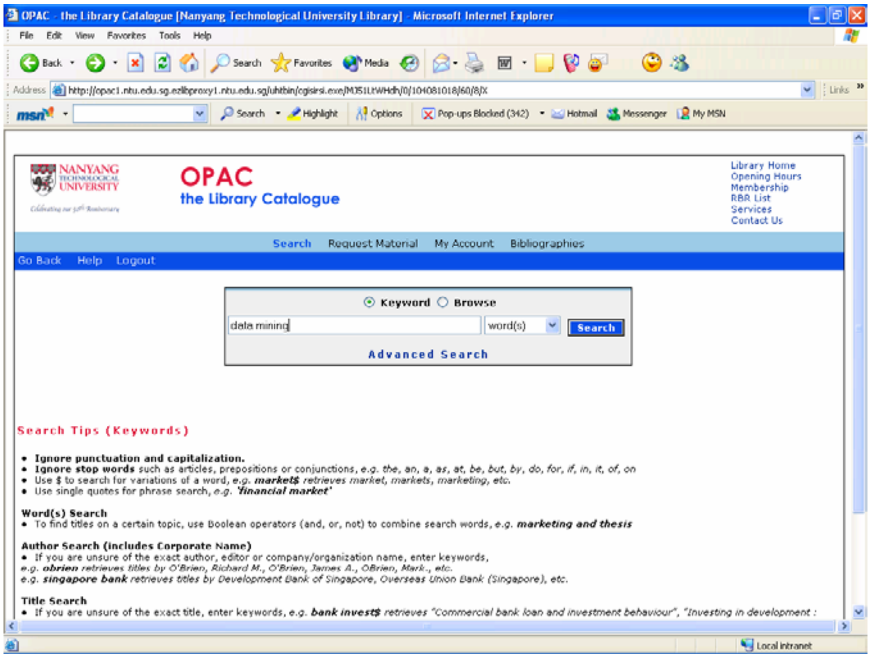

Fig.4. The NTU OPAC System.

3.2 Tasks

In line with the first objective of determining the types of tasks users could benefit from when using the CQE, two categories of tasks were created: clearly specified tasks and unclearly specified tasks [8]. Each category contained two tasks. The clearly specified tasks required specific and explicit information, e.g. "Find the book with the title 'Managing data mining technologies in organizations' and record the bibliographic information of this book". In this case, the information need for clearly specified tasks are straightforward and precise which in turn can be expressed by a simple query on a certain field or attribute of the information source. For the previous example, the user could obtain the desired information by simply using the title of the book as a query. Unclearly specified tasks on the other hand, have requirements that cannot be stated precisely [8], e.g. "Find 5 relevant journals related to information seeking behavior". Put differently, the information needs for unclearly specified tasks are vague and usually involve iterative query reformulation. Table 1 shows the tasks designed for the study.

Table 1. Tasks Used in the Study

	Clearly Specified Tasks	**Unclearly Specified Tasks**
1	Find the proceedings of the Third International Semantic Web Conference. Record bibliographic information of this book.	Determine whether Singapore citizens are satisfied with the quality of traditional Chinese pharmacy available in the market.
2	Find the document with the name **"**Developing a common set of agents for E-commerce". Record bibliographic information of this document.	Find 10 international journals related to information retrieval and record the editors' names of these journals.

3.3 Experiment Design

The 16 participants were randomly divided into four groups of four participants each (Table 1). Groups A and B used the CQE to complete the clearly specified and the unclearly specified tasks respectively. Participants in Groups C and D used the existing OPAC system to complete the clearly specified and the unclearly specified tasks respectively. Participants in Group A and B were given a 10 minute introduction of the CQE followed by a practice session before carrying out the tasks. Participants in Groups C and D were introduced to the CQE after they had completed the tasks using the OPAC, and then asked to try the system. The time taken to accomplish the tasks successfully was recorded and used to measure the usefulness of the CQE, which is similar to that done in [8]

At the end of the study, all participants were asked to complete a preference questionnaire about the CQE. We adopted Nielsen's heuristic evaluation approach [7] to assess the usability of the system. This technique is used to find usability problems by getting a small number of evaluators to examine an interface and judge its compliance with ten recognized usability principles. The goal is to obtain the most useful information for guiding re-design with the least cost. Here, each heuristic is reflected by one or more questions concerning the design of the system. Each question is rated along a five-point scale – "strongly disagree", "disagree", "neutral", "agree" and "strongly agree".

3.4 Results and Discussion

Table 2 shows the average time needed for each group to finish the tasks. Compared with Group D, participants in Group B exhibited a major reduction in terms of average time to complete the unclearly specified tasks. This suggests that the CQE helped participants find the desired information more quickly than using the OPAC system alone for unclearly specified tasks. In other words, it appears that collaborative querying can help users formulate better queries by harnessing other information seekers' knowledge and reduce the time needed to sift through search results documents in search of relevant content when the information needs are vague and difficult to express. The reason is that most users cannot formulate a precise query to represent their information need in the first round of search. This leads the participants in Group D having to spend more time sifting through the results listings and reformulating their queries. However, for the participants in Group B, they were able to formulate better queries by either harnessing the recommended queries or exploring the QGV which in turn reduced the time in examining the results listings.

On the other hand, there is no noticeable difference between Groups A and C in the time required to complete the clearly specified tasks accurately. This suggests that collaborative querying has no time advantage in the process of information seeking for clearly specified tasks. The reason here is that all users could formulate an accurate query to express their information need and retrieve the target information in the first iteration of search. Further, the target information was easily found in the search results listings and typically occurred on the first results page returned by both the CQE and the NTU OPAC.

Table 2. Average Task Completion Time for Each Group

	Clearly Specified	**Unclearly Specified**
CQE	3 min (Group A)	12.5 min (Group C)
OPAC	3 min (Group B)	22 min (Group D)

As for usability, the CQE satisfies most of Nielsen's 10 heuristics according to our 16 participants (see Table 3). Due to space limitations, we show the results as numeric values (1-5) and only report the average value obtained for each heuristic. Here, higher values represent a greater level of agreement that the CQE adhered to the corresponding heuristic. As shown in Table 3, users agreed that the CQE adhered to most of Nielsen's 10 heuristics, with scores of four ("agree") or higher. For example, in "visibility of system status", 14 participants rated 4 or 5 (average value of 4.1) which indicated that they agreed or strongly agreed that the CQE provided enough information to reflect the action status of the system. As far as "consistency and standards" was concerned, 12 participants rated 4 or 5 (average of 3.8) which implies that they were comfortable with the layout and graphic design of the CQE and agreed that the font size, color, buttons, text box and popup menus were consistent with existing user interface standards. The results thus indicate that the CQE performs well in terms of usability issues.

In addition, qualitative remarks about the CQE confirmed the usability and usefulness of the system. Here, positive features included the recommended query lists being able to give users more ideas on what query terms to use, and the usefulness of the graph visualization scheme which specifies the relationships between queries with varying weights. For example, one participant commented that:

"it was a helpful system to better understand the domain I am searching. Based on the recommended queries, I know how other people search for documents of my interests. The relationships between the recommended queries are clearly shown. By using the recommended terms to construct my queries, I get the relevant documents quickly".

Participants also commented that the system made searching more "fun" due to the graph visualization approach and the ability to explore the query nodes.

Negative comments go to the lack of detailed documentation which was needed to support the successful use of the system and was reflected in the low score of the "help and documentation" heuristic (average of 2.3). This low score could be attributed to the fact that some technical terms were used in the system, such as "nodes" and "weights". Despite this, 13 of the 16 participants expressed a strong interest in the system, and indicated that they would use the CQE if it became publicly available in the future.

Table 3. Heuristic Evaluation Summary of the CQE

Heuristic	Average value
Visibility of system status	4.1
Match between system and real world	3.3
User control and freedom	4.5
Consistency and standards	3.8
Error prevention	4.8
Recognition rather than recall	4.4
Flexibility and efficiency of use	4.8
Aesthetic and minimalist design	4.8
Help user recognize, diagnose and recover from errors	4
Help and documentation	2.3

4 Conclusion

This paper presents the CQE and reports on its evaluation. The CQE is a collaborative querying system and operates by harnessing the collective knowledge embedded in query logs to assist users in query formulation. Harvested queries can be used directly as recommendations for query reformulation or visualized in a graph format for exploration.

A few systems bear some relevance to the CQE in their support for collaborative querying. For example, Glance [5] developed an agent known as the Community Search Assistant. However the system does not employ a graph-based visualization scheme for users to explore and interact with the recommended queries. Further, the CQE adopts an alternative query clustering approach to detect related queries that has been demonstrated to be more effective [3]. Eurekster (www.eureskster.com) is another system which adopts a community-based approach to collaborative querying through search groups of users who share similar interests. However Eureskster requires more effort by users in building the search group before the benefits of collaborative querying can be realized. In contrast, the CQE is non-intrusive and operates by comparing the user's current query and existing clusters in the query repository in the background and sharing the related queries automatically [4].

Our study shows that users can benefit from the CQE for unclearly specified tasks and that the system does not adversely affect searching performance for clearly specified tasks. This therefore suggests the viability of the collaborative querying concept. Nevertheless, our evaluation also highlighted several areas for further improvement. For example, because the graph-based mode of interaction is unfamiliar to many users, online help will need to be incorporated. However, due to the small sample size of this initial evaluation, our findings cannot be generalized. Instead, a comprehensive evaluation will be conducted to further assess the performance and effectiveness of the CQE involving more users and a greater variety of task types.

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