Design and Evaluation of a Prototype User Interface Supporting Sharing of Search Knowledge in Information Retrieval

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This paper describes a prototype user interface system, CIRR tool, which allows searchers to share their relevance judgments, search queries, and search results by providing a system Task Console with a "Group Report" feature. The system was developed based on the assumption that knowledge sharing in information retrieval (IR) is helpful and important to improve search performance. A usability evaluation of this system was conducted. The test results show that in general the system is easy to learn and use. However, some usability problems are also observed. The paper discusses these issues and proposes future research directions.

Introduction

Information retrieval (IR) is a highly intellectual task. Several types of knowledge are involved in the searching process. These include topic domain knowledge, search knowledge, system knowledge, and so on. Topic domain knowledge represents to what extent a user understands a search topic. Some studies found that domain knowledge influences users' search behavior, even though there is no consensus on its effects on search performance (Allen, 1991; Kiestra, Stokmans, & Kamphuis, 1994; Marchionini, Dwiggins, Katz, & Lin, 1993; Montaner, Lopez, & Lluis De La, 2003; Vakkari, Pennanen, & Serola; 2003; Wildermuth, 2004). However, a high-level domain knowledge helps a searcher make relevance judgments and evaluate whether search results answer the search question, regardless of the age of the user (Hirsh, 1997; Marchionini *et al*., 1993).

Search knowledge reflects the degree a user knows how to plan his/her searching, namely, search strategies that include systems selection, term selection, the use of operators, parentheses, truncation marks, and in the end, the formulation, modification, and expansion of search queries. Without doubt, search knowledge is an important factor for a successful search, especially in Boolean IR systems. For end-users without training in Boolean language, it is impossible to conduct even a simple search on this type of system because of the difficulty in constructing a search query. This is one of the reasons that Boolean IR systems incur much criticism (Cooper, 1988; Frants, Shapiro, Taksa, & Voiskunskii, 1999). Although many current search systems, for example, web search engines, enable end-users to easily conduct a search using natural language, the search behavior and performance between search experts and novices are still very different, particularly when the levels of domain knowledge are different. Studies have proved that domain search experts obtain better search performance than novice users (Bhavnai, 2002; Elkerton & Williges, 1984; Marchionini, Lin, & Dwiggins, 1990), and make fewer errors (Fenichel, 1981; Penniman, 1981; Tolle, 1983).

It is critical to have basic search knowledge for a successful search. The typical way to transfer the search knowledge to novice users is through training. During the training process, novice users share the search knowledge from experienced users. Tenopir (2004) writes that seeing expert searchers' search strategies is a great learning tool for common users. In practice, instructors teaching search skills in library and information science schools often use successful search sessions, including queries and results, as examples. Some studies also suggest that trained novices could perform as well as expert searchers (Fenichel, 1981; Meadow, Wang, & Yuan, 1995; Vakkari *et al*., 2003).

However, given that search has become a common task in our daily life, it is impossible to systematically train each single novice user in searching. It is thus desirable that information technology should be developed to support the sharing of this knowledge among users. To date, there are still few studies or interface designs focusing on this issue. On the basis of Bhavnani's (2002) findings, Bhavnani *et al*. (2003) propose a design named Strategy Hubs, which embeds into the system the expert search procedures for the healthcare domain to assist the uninitiated searchers to advance their search performance. The results indicate that it does help the novices improve their search performance, especially when searching on difficult questions and the comprehensive questions assigned by the researchers. However, this is only one way to share search knowledge. It is believed that there are other approaches to sharing search knowledge, for example, to develop a knowledge sharing mechanism in system design so that novices can review other searchers' queries, results, and relevance judgments.

In this paper, we describe the design and an evaluation of a user interface system that supports sharing of search knowledge in IR. The evaluation described in this paper focuses on the usability issues. In the following section, we review the related research on the support of knowledge sharing in information systems. Then we describe the prototype user interface system designed for the study. The results of the usability evaluation of this system are reported in the next section. The paper is concluded with future research directions.

Related work

Research on the information systems that support knowledge sharing can be found in various fields, such as information science, collaborative filtering recommender systems, knowledge management, and CSCW.

Collaborative filtering recommender systems imply the sharing of expertise, but not explicitly. In such systems, recommendations are provided to users by others the user may not know (Resnick & Varian, 1997). Recommendations from other people represent the experience and judgment of a community (Zhang, 2002). Montaner, Lopez, and Lluis De La (2003) provide a thorough review in this field. Collaborative recommendations can fruitfully complement content-based information retrieval techniques based on the text contents. Theoretically, the collaborative method can make the product of a previously successful search results available to other users. A user with low personal experience/knowledge can benefit from others' prior experience. However, human beings' search

expertise is not directly available to other users. Therefore, recommender systems alone cannot solve the problem when a user needs help in finding relevant documents but the system has nothing to recommend.

Efforts have been made in IR related system implementations. For example, Twidale and Nichols (1998) introduce the ARIADNE system as an example of computerized support for collaborative browsing in a library catalog system. The system supports only collaborative browsing, not search activities, and it supports collaborative activities only for small groups of people. When constructing search agents for users, Newell (1997) found that instead of simply conducting a search using traditional methods, a user may obtain better search results by using an existing agent created by another user with a similar background to do a similar search. The search results generated by the existing agent would be of interest to this user. Romano, Roussinov, Nunamaker, and Chen (1999) describe a prototype system, CIRE, which combines the features of IR and group support systems and attempts to solve the problem of individuals searching independently in IR. The system has the following features: (1) Users may view the team queries. If the queries have been annotated, the annotations are also presented in a second window. (2) Users may request to see the list of pages that the team has visited. While browsing the search results, users can submit annotations, respond to others' annotations, or submit an evaluation of the page in terms of relevance to the search task. (3) User observations with the initial prototype revealed that the ability to browse other team members' comments, view pages visited by other team members and read query annotations were frequently forgotten or ignored features. These may be due to inadequate interface design. One limitation of the system is that it is designed for small working teams rather than the general public. AntWorld (Kantor *et al*., 2000) is a collaborative Web IR system that captures human intelligence: people's relevance judgments on retrieved Web documents. The system enables people to share relevant searches by using the collaborative filtering recommendation method. However, no explicit sharing of search queries is supported.

Hust, Klink, Junker and Dengel (2003) propose a new query expansion method based on the collaborative IR concept: to use the terms in globally available similar search queries to expand the current query. Their experiment shows the method has some advantages compared to the conventional query expansion methods. The idea of query reuse is explored by Balfe and Smyth (2004).

Systems that are based on the idea of sharing knowledge can also be found in the field of knowledge management. Such systems normally are expert finding systems that can locate an expert in an organization. Linton (2003) presents OWL, a system that supports sharing of the expertise related to the use of software, such as Microsoft Office. Maybury, D'Amore and House (2003) describe an

Expert Finder system for the expertise management in MITRE Corporation. Yimam-Seid and Kobsa (2003) present another system, DEMOIR, as an expert-finding system. This kind of system does not support IR tasks.

In addition to the system implementations discussed above, Collaborative Information Retrieval (CIR) behavior has been studied by Bruce *et al*. (2003). In their study of two industry design teams, the authors observed how the members of the teams solved design problems through collaborations in information seeking. It should be noted that the collaboration behavior observed in small teams or groups may be very different from the behavior of knowledge sharing or collaboration that is supported by the system we discuss in this paper, because the users do not know each other in our system settings. This is a great challenge to the design of knowledge sharing systems that are different from group support systems

CIRR tool: a prototype user interface system

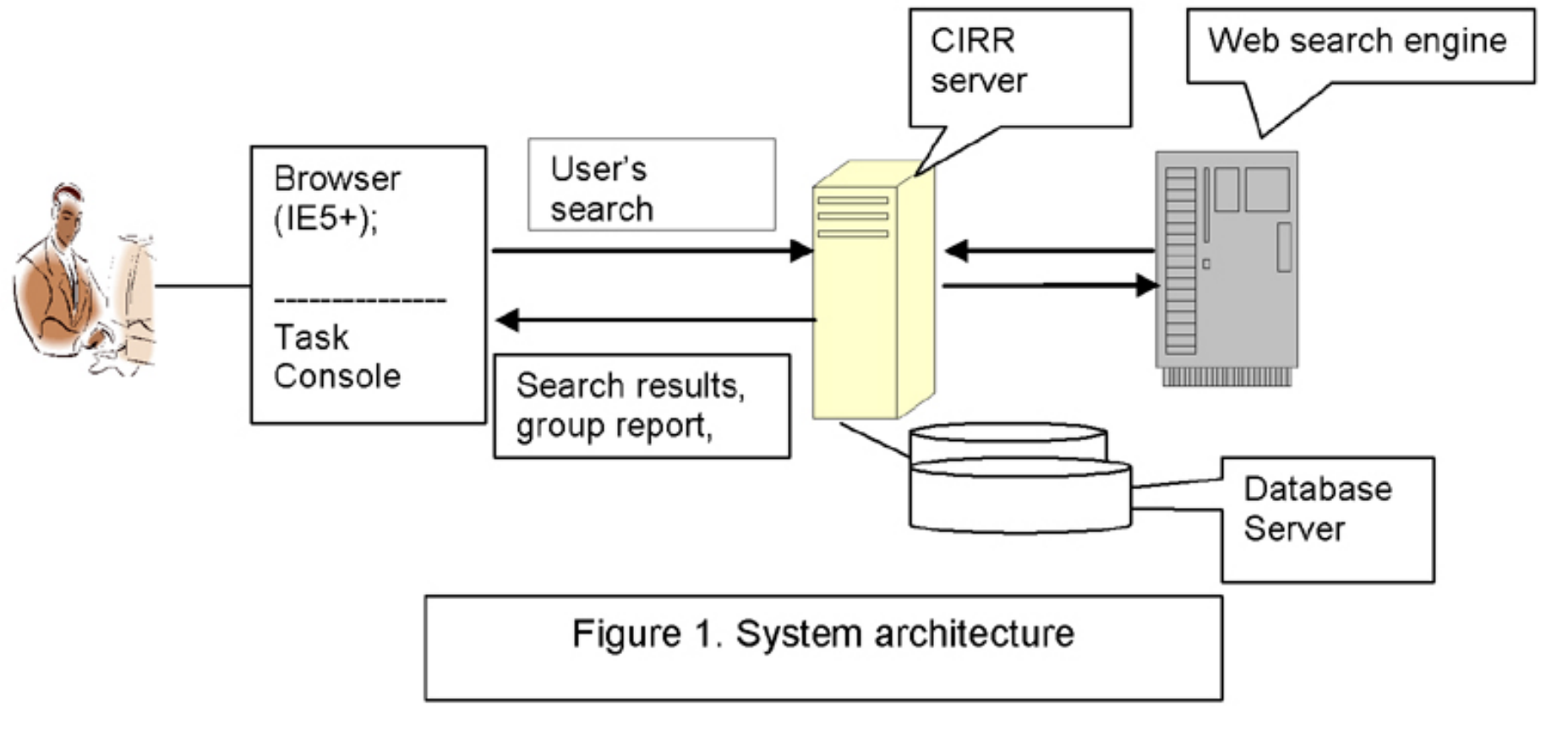


Figure 1. System architecture

CIRR (Collaborative Information Retrieval Research) is designed as a research tool for collaborative IR experiments. The system is designed to support the sharing of search knowledge among users who search the Web using search engines. The current system has the capability of facilitating relevance judgments, annotating documents, and recording the search sessions, including search queries, retrieved document URLs, relevance judgments and annotations. The data collected are analyzed to compare the user search performance under different conditions. In order to run experiments, the system allows pre-loaded search topics, creating and configuration of user groups, collection of user data through both pre- and post-search questionnaires, and reporting of searching

task progress.

System architecture

The prototype system features a 3-tier architecture: It uses a Web server as the middleware, a web browser as the client program, and a relational database server as the backstage storage device for collecting data. The system serves as a user interface to search engines. Currently the underlying search engine is Google. The user uses a regular web browser, supported by our Web server, to access the Internet and the data stored in our database. The server parts of the system are running on a Sun workstation with the Solaris OS, version 10. Not all of the desired functions have been implemented. The prototype system currently consists of the following major components:

- A web server that supports Java Servlets and JavaServer Pages
- A relational database server
- A web browser
- A system task console that provides the functionality for user tasks

Web Server. The public domain TOMCAT java server (v.4) is used as the web server of the system. This server conforms to the Servlet 2.3 and JSP 1.2 specifications from Java Software.

Database Server. We use the Sybase Enterprise server as the backend storage device for the data the system collects. This database server is a relational database management system. We use JDBC to connect the web server to the database.

System Task Console. The system task console is a JavaScript application that runs on the client computer, and is supported by the web server and a set of JSP applications. The console provides the user with the functions that facilitate running experiments, including search knowledge sharing features. A detailed description of the console is given below.

Web Browser. A web browser serves as the client program to access the server. The system is designed for Internet Explorer version

5+. Netscape version 4+ was initially supported, but due to a very small number of users, this support has not been continued.

The system architecture is presented in Figure 1.

The task console

The task console is a JavaScript application. It serves as a user interface to the system's database server: save and retrieve data to and from the database. As a system that intends to facilitate knowledge sharing for searches, the task console provides the major functions for fulfilling this goal. It has the following functions: relevance judgments recording, annotation recording, and group report display that makes previous searchers' search queries and results on the same topic available. All these functions are part of the Task Console Window, whose screen shot is depicted by Figure 2.

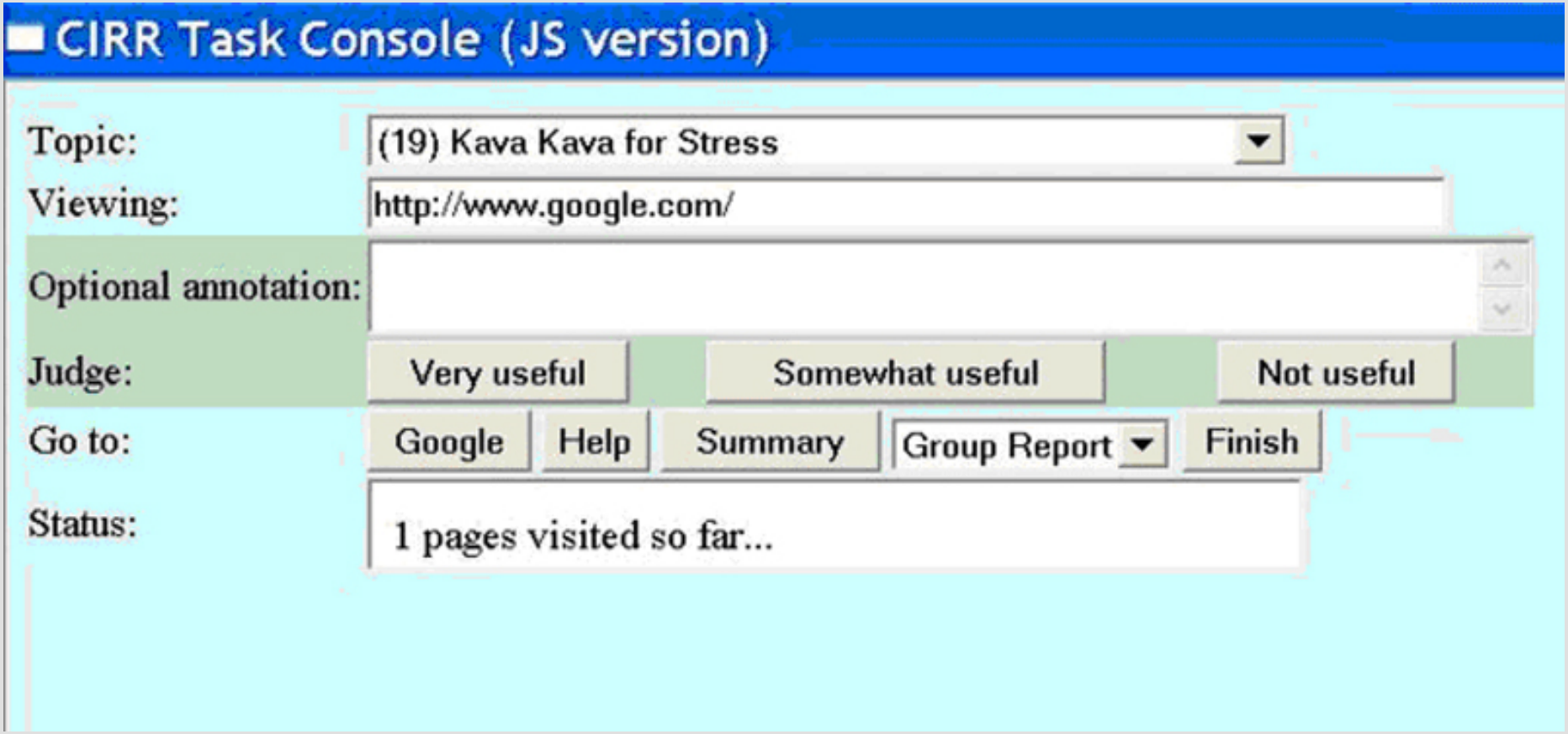


Figure 2. The task console window

The system's task console was initially implemented as a JAVA applet. This applet did not work well with different platforms and frequently crashed. We then developed a JavaScript version of the task console, and it has been working relatively stable. The web browser handles the Java applets and JavaScripts internally in very different ways, but it does not affect the system operations. As a side benefit, using JavaScript also reduces the number of windows from the initial 4, using the applet version, to 2.

In Figure 2, on the top of the window, the field "Topic" displays the current search topic that the user is working on and allows the

user to select a search topic they wish to work on from a drop-down menu. Since the major purpose of the system is to conduct experiments, the search topics are pre-defined and loaded into the system so that all participants can search on the same set of topics.

The next field, "Viewing," indicates the URLs of the websites that the user is currently viewing. The "Optional annotation" field allows users to enter in comments to include with their judgments on a particular page. The three buttons, "Very useful," "Somewhat useful," and "Not useful," allow the user to judge each retrieved page according to the relevance of the website to the particular search topic. The three choices are corresponding to the three values used in TREC experiments: soft on topic, not on topic, and right on topic (Allan, 2004). The user can simply click on one of the buttons to record the judgment. Whenever a judgment is made using one of these buttons, the "Status" field, at the bottom of the screen, provides users with feedback, thanking the user for their judgment and reporting the number of judgments that have been made during the search session.

The series of buttons above the "Status" field allow the user to navigate the system fairly quickly: the "Google" button takes the user to a fresh Google page, the "Help" button takes the user to the User Guide, the "Summary" button allows a user to track their progress on a search topic, the "Group Report" drop-down menu allows a user to view judgments and search queries of other users in his or her group (Details about this function is described in the following section.), and finally, the "Finish" button offers the user a chance to answer a post-search questionnaire.

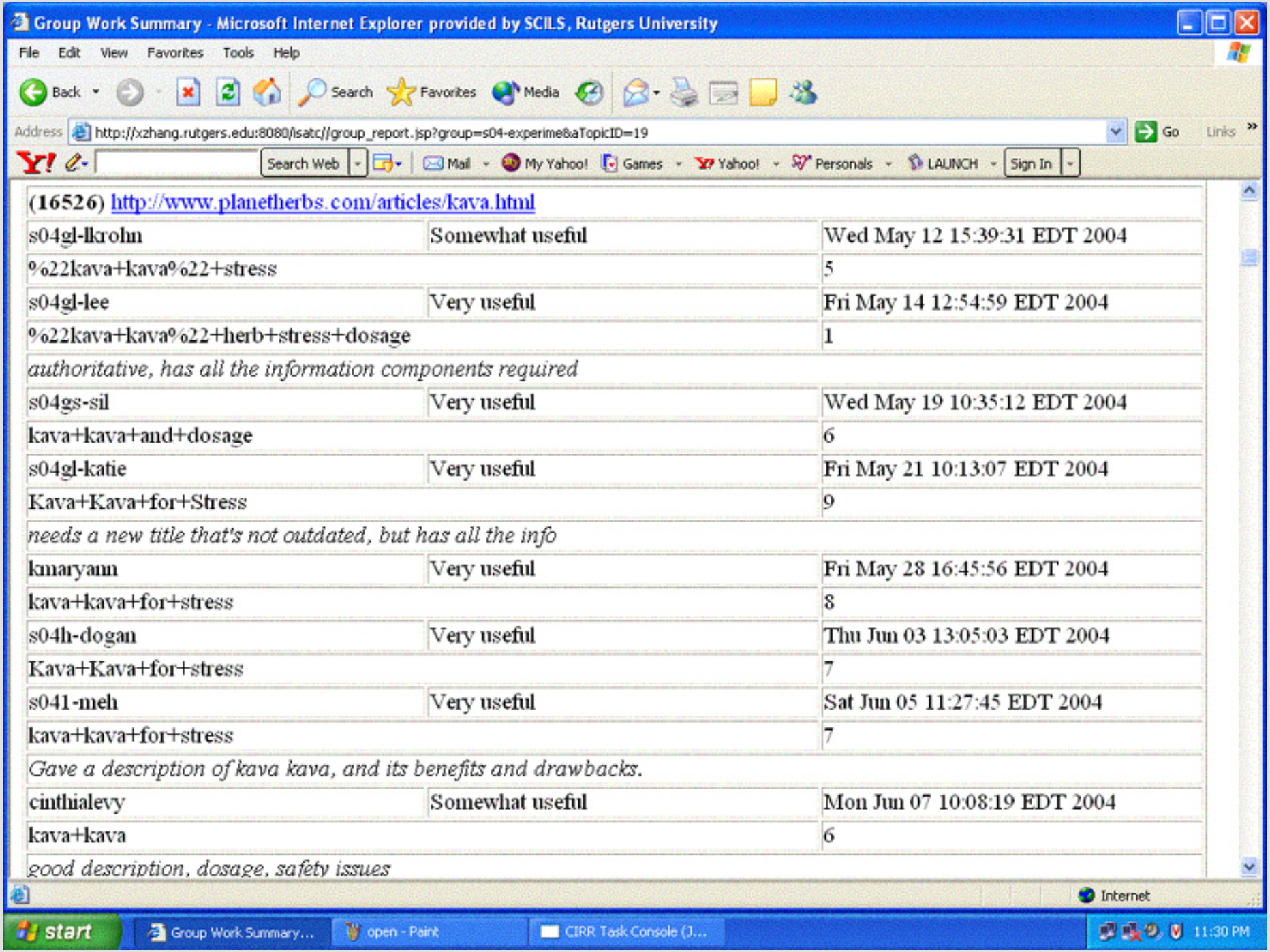
Among these functions, "Judge," "annotation," and "Group Report" are considered as the features that support sharing of knowledge. When the user makes judgment on and/or enters annotation for a document the user is giving his/her knowledge so that other users can share. When the user views the group report, the user is sharing other users' search results which contain both topic domain knowledge and search knowledge.

Group function: Sharing of other searchers' results

The system's group function is currently the major tool for facilitating sharing of search knowledge. It has two major features. The first is creating and managing user groups based on their background, search interests, and perhaps on some other user

characteristics. Management of groups include activating and inactivating a group; removing/deleting a group; and changing the membership of a group. A web interface is developed for the administrator to perform these tasks. When a new user registers with the system, the user registration screen provides all existing groups. The new user will have to join at least one of the groups to create his or her account. Each user can be members of multiple groups. The second feature is that the console contains a dropdown menu called "Group Reports," with all existing user groups listed there. The user can select any of the groups. Upon selection, a "Group report" will be generated and loaded into the browser (also called document) window. This is similar to what happens when the user clicks on "Summary" and the user's own activity summary is loaded into the document window. The report includes records of the activity of all users from the chosen group on the current topic. It provides the URL, the judgment(s) made by all users in the group, the username of the user who made the judgment, the date and time the judgment was made, the ranking position of the website in Google's search result list, and the search query that was used to find the website. The user can view this report for a particular document to see other people's judgment, or for other people's search queries to see how the document was retrieved.

The contents of the group report reflects the search knowledge other searchers have on the current search topic, and we assume this knowledge be helpful for the current user to find useful information. A sample of the group report is displayed in Figure 3.


Group Work Summary - Microsoft Internet Explorer provided by SCILS, Rutgers University
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://xzhang.rutgers.edu:8080/isatc//group_report.jsp?group=s04-experime&aTopicID=19
Go Links
Search Web Mail My Yahoo! Games Yahoo! Personals LAUNCH Sign In
(16526) http://www.planetherbs.com/articles/kava.html
s04gl-lkrohn Somewhat useful Wed May 12 15:39:31 EDT 2004
%22kava+kava%22+stress 5
s04gl-lee Very useful Fri May 14 12:54:59 EDT 2004
%22kava+kava%22+herb+stress+dosage 1
authoritative, has all the information components required
s04gs-sil Very useful Wed May 19 10:35:12 EDT 2004
kava+kava+and+dosage 6
s04gl-katie Very useful Fri May 21 10:13:07 EDT 2004
Kava+Kava+for+Stress 9
needs a new title that's not outdated, but has all the info
kmaryann Very useful Fri May 28 16:45:56 EDT 2004
kava+kava+for+stress 8
s04h-dogan Very useful Thu Jun 03 13:05:03 EDT 2004
Kava+Kava+for+stress 7
s041-meh Very useful Sat Jun 05 11:27:45 EDT 2004
kava+kava+for+stress 7
Gave a description of kava kava, and its benefits and drawbacks.
cinthialevy Somewhat useful Mon Jun 07 10:08:19 EDT 2004
kava+kava 6
good description, dosage, safety issues
Internet
start
Group Work Summary...
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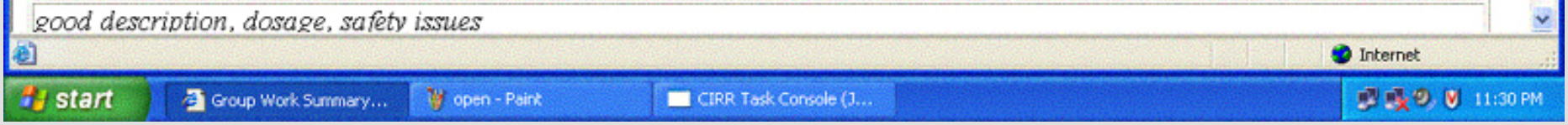


Figure 3: The group report

A brief usage scenario

Before a user can begin using the system, the individual must register, which involves creating a username and password as well as completing a short pre-search questionnaire. Once a user has registered, he or she can log in to the system in order to begin searching. The welcome page of the system offers users the chance to recognize why the system was created and for what it is intended (see Figure 4).

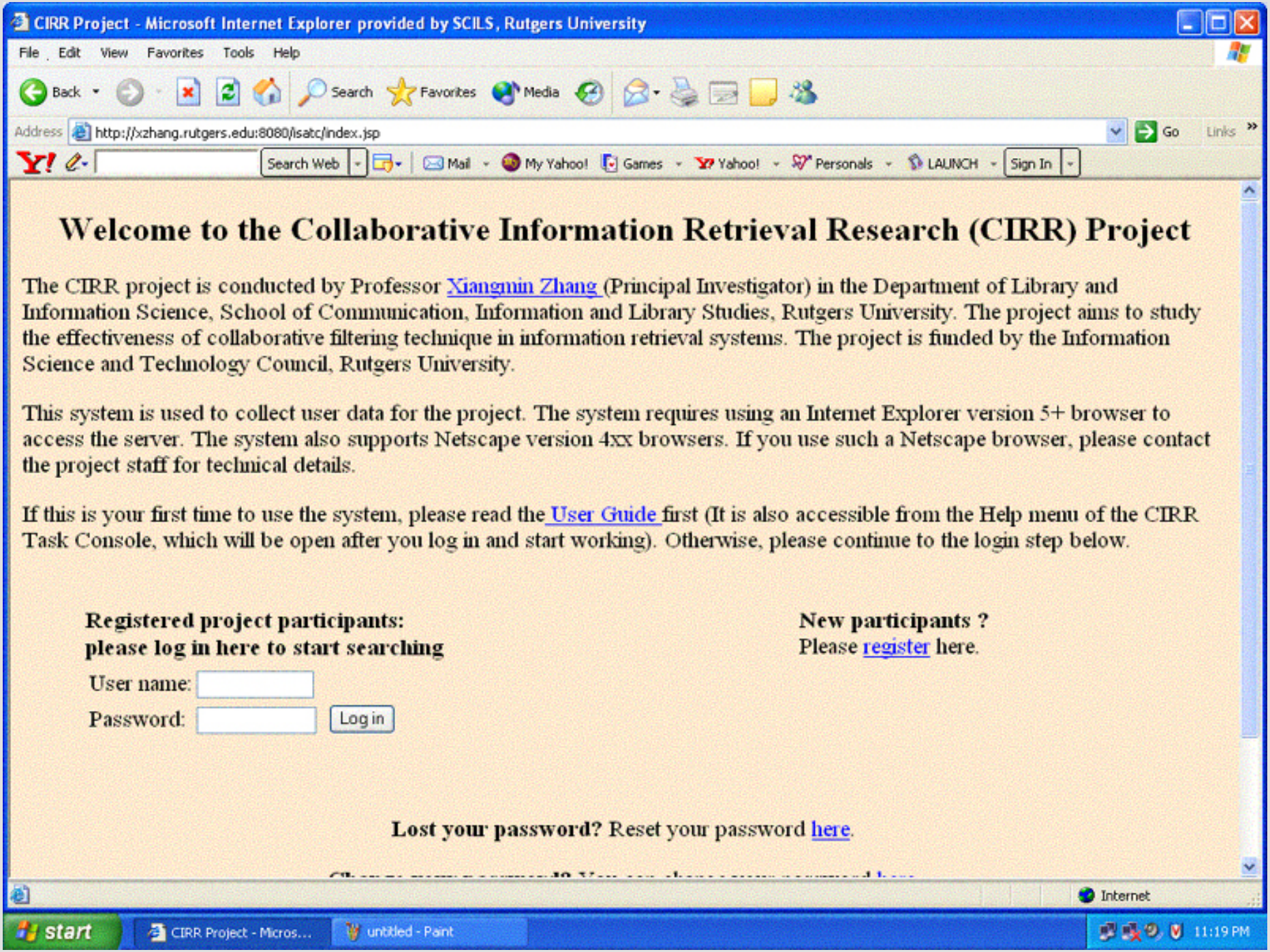
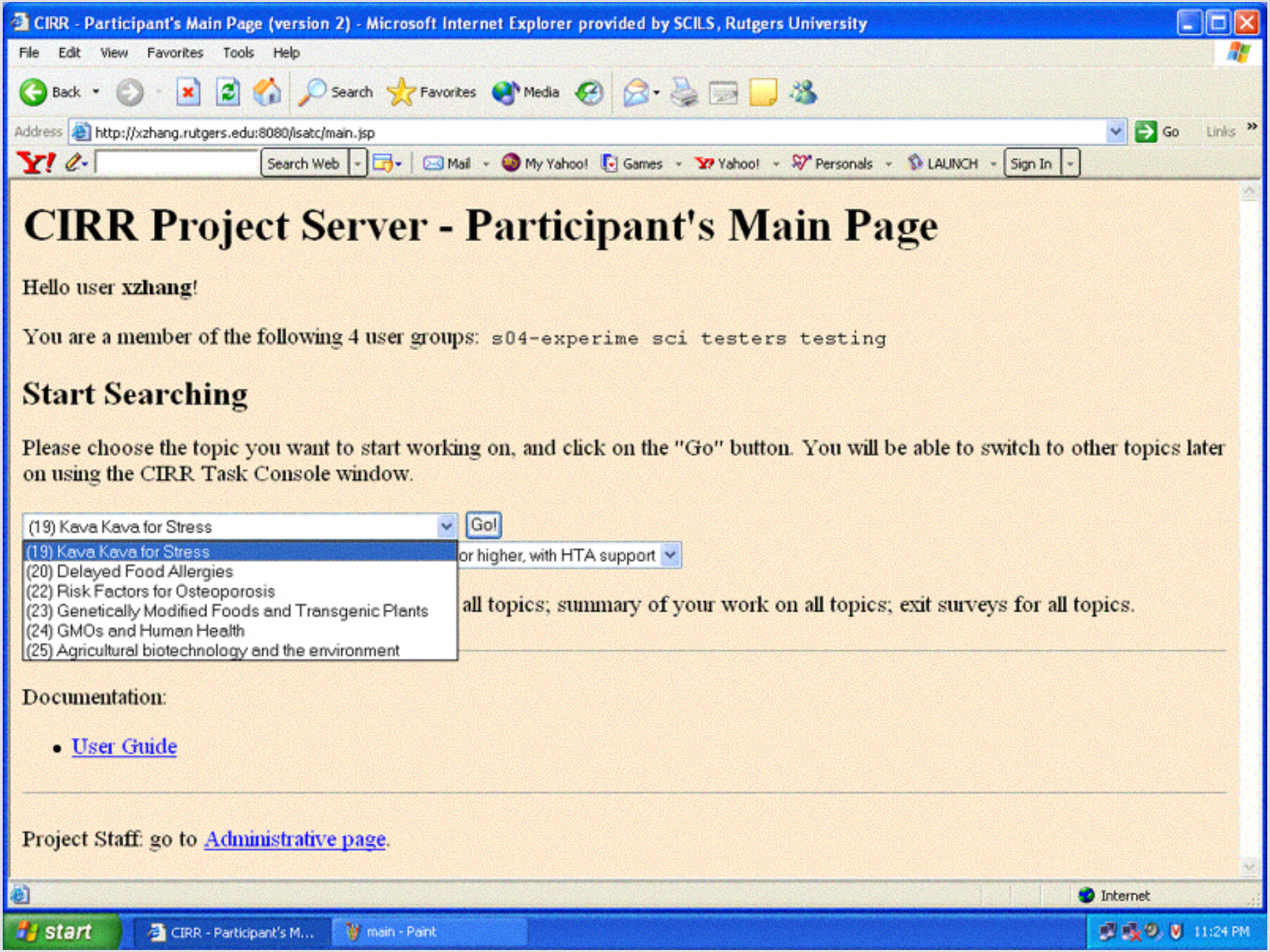

CIRR Project - Microsoft Internet Explorer provided by SCILS, Rutgers University
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://xzhang.rutgers.edu:8080/isatc/index.jsp
Go Links
Search Web Mail My Yahoo! Games Yahoo! Personals LAUNCH Sign In
Welcome to the Collaborative Information Retrieval Research (CIRR) Project
The CIRR project is conducted by Professor Xiangmin Zhang (Principal Investigator) in the Department of Library and Information Science, School of Communication, Information and Library Studies, Rutgers University. The project aims to study the effectiveness of collaborative filtering technique in information retrieval systems. The project is funded by the Information Science and Technology Council, Rutgers University.
This system is used to collect user data for the project. The system requires using an Internet Explorer version 5+ browser to access the server. The system also supports Netscape version 4xx browsers. If you use such a Netscape browser, please contact the project staff for technical details.
If this is your first time to use the system, please read the User Guide first (It is also accessible from the Help menu of the CIRR Task Console, which will be open after you log in and start working). Otherwise, please continue to the login step below.
Registered project participants:
please log in here to start searching
User name:
Password:
Log in
New participants ?
Please register here.
Lost your password? Reset your password here.
Internet
start
CIRR Project - Micros...
untitled - Paint
11:19 PM

Figure 4: Welcome page to the CIRR system

Once a user has logged in, the Participant's Main Page is retrieved from the server. This page identifies the


CIRR - Participant's Main Page (version 2) - Microsoft Internet Explorer provided by SCILS, Rutgers University
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://xzhang.rutgers.edu:8080/isatc/main.jsp
Go Links
Search Web Mail My Yahoo! Games Yahoo! Personals LAUNCH Sign In
CIRR Project Server - Participant's Main Page
Hello user xzhang!
You are a member of the following 4 user groups: s04-experime sci testers testing
Start Searching
Please choose the topic you want to start working on, and click on the "Go" button. You will be able to switch to other topics later on using the CIRR Task Console window.
(19) Kava Kava for Stress
Go!
(19) Kava Kava for Stress
(20) Delayed Food Allergies
(22) Risk Factors for Osteoporosis
(23) Genetically Modified Foods and Transgenic Plants
(24) GMOs and Human Health
(25) Agricultural biotechnology and the environment
or higher, with HTA support
all topics; summary of your work on all topics; exit surveys for all topics.
Documentation:
User Guide
Project Staff: go to Administrative page.
Internet
start
CIRR - Participant's M...
main - Paint
11:24 PM

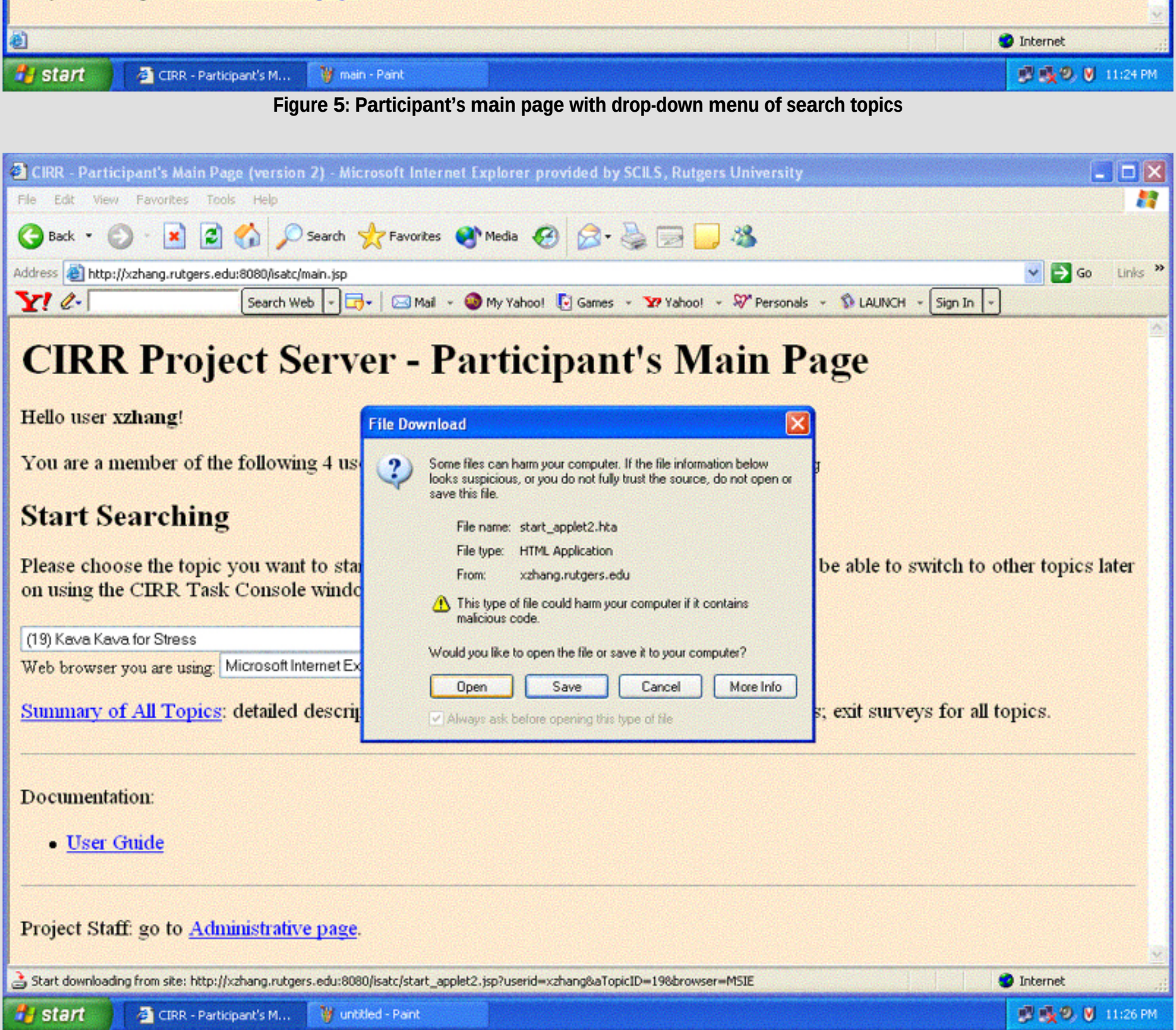


Figure 5: Participant's main page with drop-down menu of search topics

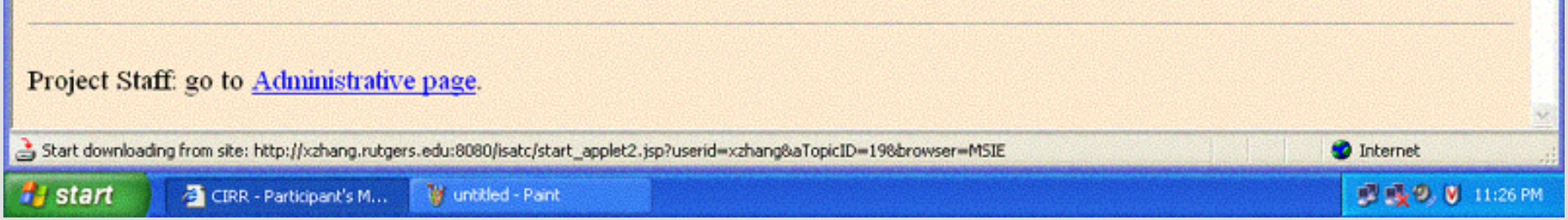


Figure 6: Starting the CIRR task console

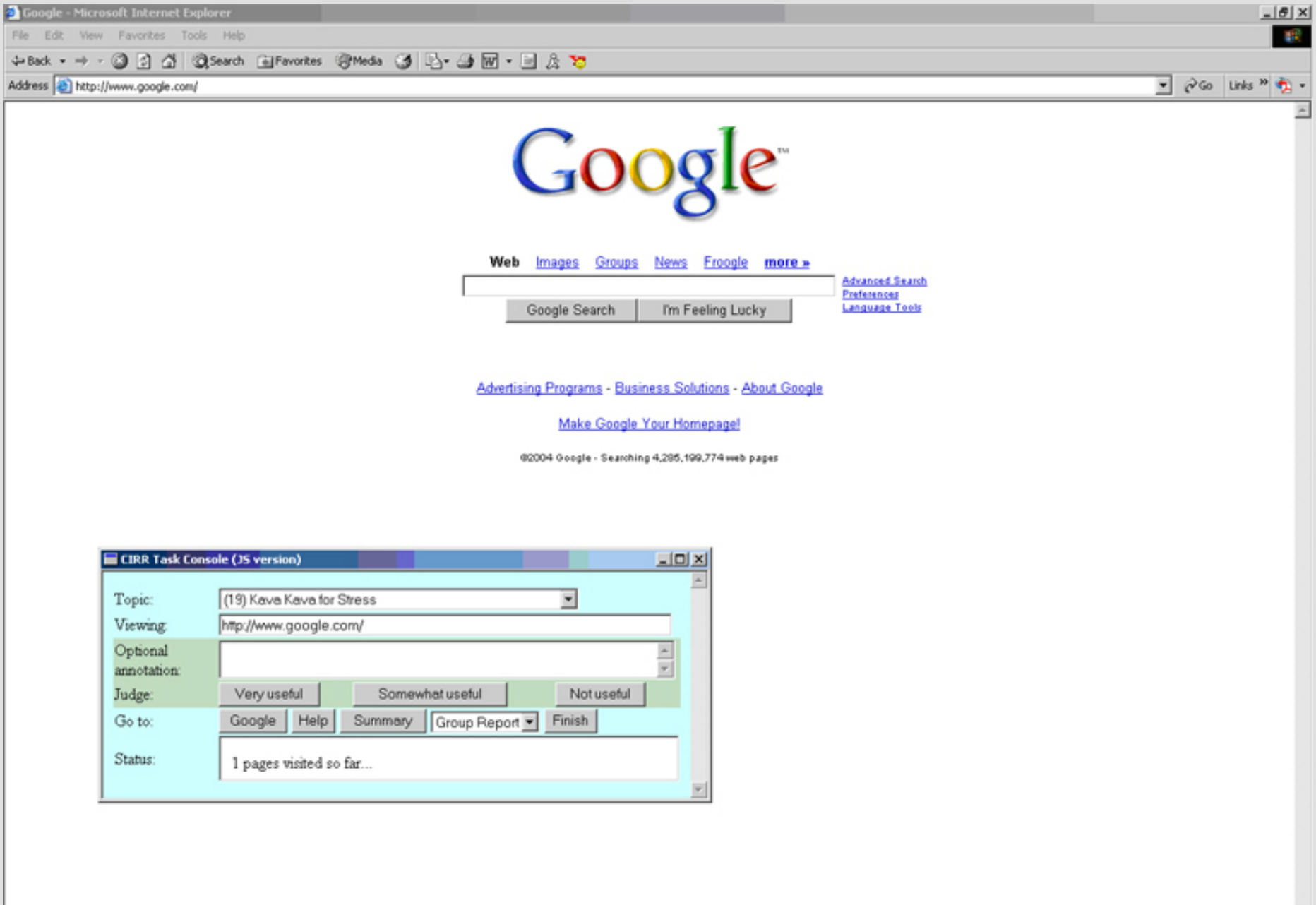


Figure 7: The CIRR task console with the search window in the background.

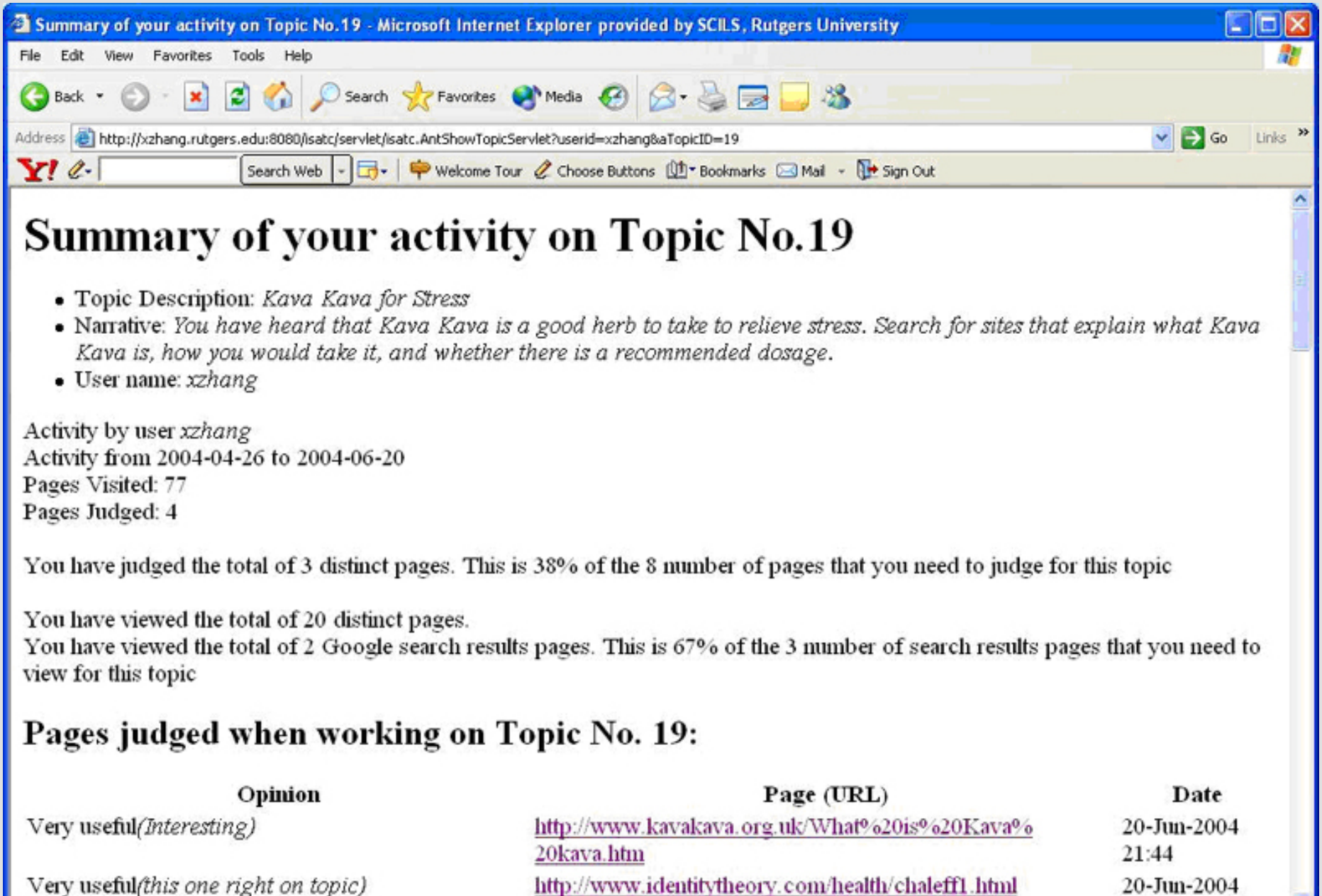
user by username and reports if the user is a member of any groups. It also allows the user to read the User Guide or a summary of all the search topics available on the system.

Once the user is ready to begin searching, he or she can choose the search topic from the drop down menu and click the button "Go!" to start the CIRR Task Console Window (see Figure 5). At this point, the user is presented with an alert pop-up window entitled "File Download," where the user is offered four choices of action that can be done with the file that is about to be downloaded (see Figure 6). This pop-up is a built-in alert in Microsoft Internet Explorer, and cannot be altered by the researchers. The pop-up alerts the user to the potential dangers of an HTA file (HTA files can contain fairly powerful code and should only be downloaded from trustworthy sources). The user should select "Open," an action which will allow the CIRR Task Console to be downloaded and start running, while a second window, the document window, presents the user with the chance to search the web using Google (see Figure 7).

In order to search on the assigned topics and make judgments on the relevance of the websites retrieved, the user must switch back and forth between these two windows.

The CIRR task console offers the user a number of features (see Figure 2 and Section "The task console" above). While a user is searching for websites relevant to a topic, he or she may wish to view the Group Report, which provides a list of websites that were judged by other group members (see Section "Group function" above and Figure 3).

Users may also want to track the progress of their own searches. The "Summary" button in the Task Console returns to the user the history of the current user's websites judged, the recorded URLs, judgments, comments, and corresponding date and time (see Figure 8).



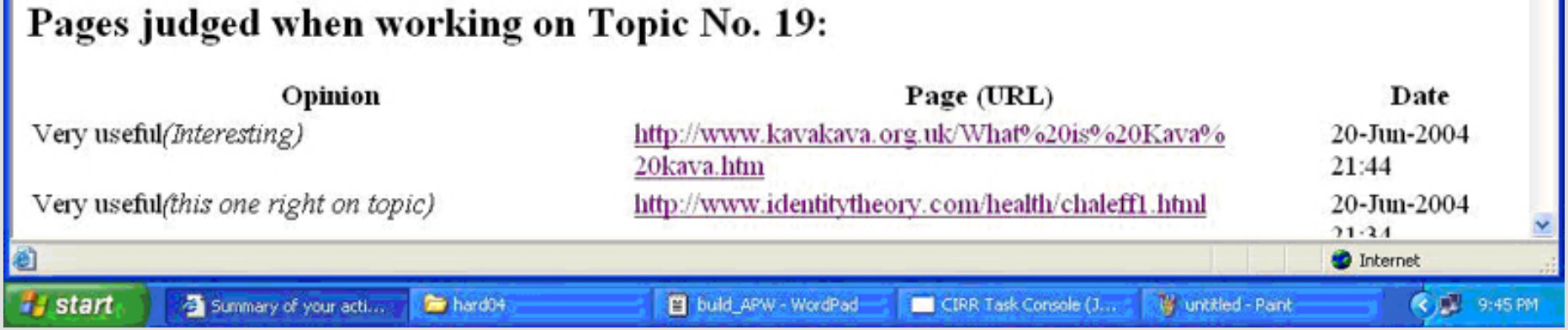


Figure 8: Viewing the summary of a user's progress on a search topic

At the top of the Summary page, the user's progress is summarized with a tallying of the number of websites judged, as well as a report of the number of Google search pages viewed. These numbers are reported both in integer form as well as in percentage form (the percentage reports how much "required" searching has been done, according to the rules of the experiment).

When the user has finished searching on the topics for the moment, he or she only needs to close or quit the internet browser in order to log out of the system, and the judgments that have been made will already have been recorded and saved for the next search session.

System evaluation

The evaluation described in this paper focused on the prototype system's usability and the usefulness of the collaboration features. We wanted to see if the system would be usable in general and to see if the group report feature would be helpful supporting search tasks in particular. More detailed analyses on what factors would impact the users' collaboration behavior when using this system is reported elsewhere in Zhang & Li (2005).

Methods

Participants: **Sixteen Rutgers graduate students were recruited as the subjects. These graduate students were from a variety of disciplines, including library science.**

Instruments: **A pre-search questionnaire was used to collect the participants' demographic data, including their search experience. A post-search questionnaire was used to collect the participant's self-assessed prior knowledge level about the topics to be searched and their satisfaction with their search results for each topic. An exit questionnaire was used to collect the participants' opinion regarding the system's usability issues and the usefulness of the group report feature. The participants' search sessions were also video-taped to collect the participants' verbal protocols and their thinking-aloud process.**

User tasks: **Six search topics on health and genetically modified food were provided to the participants to search using the system. The topics were constructed in a format similar to those in TREC experiments.**

Procedures: **The experiment was conducted in a usability lab. Participants were asked to read the instructions and the system's user guide before they started. They then created their own user names on the system. During the registration process, they would fill out the pre-search questionnaire. Each subject was also given a quick demonstration on how to use the system. The group report feature was emphasized during this process and the subject was encouraged to use this feature. The subject then would conduct the search on the topics in the assigned order. After the search was completed, the subject needed to fill out a post-search questionnaire. The post-search questionnaire could be completed either after each search topic was done or after all search topics were done. At the end of the process, an exit questionnaire would be administered to the subject. During the search process, the subjects were asked to think-aloud and their thinking-aloud protocols were recorded.**

Results and discussion

General system usability. **The subjects' verbal protocols show that in general, all participants were able to complete all the tasks without major difficulties using the system. The subjects' mean ratings on the general usability questions, based on a five-point Likert**

scale from "Disagree" (1) to "Strongly agree (5)," in the exit questionnaire are listed in Table 1 below:

Table 1: General system usability ratings

Questions	Mean ratings
This system is easy to learn	4.13
This system is easy to use	4.19
This system supports me to complete the search tasks well	3.75
Instructions are clear and helpful	4.00
The user guide is clear and helpful	3.38
The summary of all topics are helpful	4.06
The CIRR Task Console is easy to use	4.19
Overall, I am satisfied with the whole process of working with this system	4.06

The table shows that the subjects rated the items "the system is easy to use" and "the CIRR Task Console of this system is easy to use" highest. Particularly, because CIRR Task Console is a major component of this system, to some extent, this highest score indicates the high usability of this system. This is due to the fact that besides the additional functions the task console provides in support of search knowledge sharing, the search process is the same as the subjects normally do, and Google is the search engine most subjects are in favor of and familiar with on the basis of the data collected by the pre-search questionnaire.

Usability of the group report feature. **The group report feature is an important component of this system, by which the subjects could share their queries, results, usefulness judgments, and annotations. Despite an explicit introduction to it at the beginning of the**

experiment, the subjects could choose not to use it. We expected that the subjects could realize the availability of this new feature and use it to help their searching.

We found that among 16 subjects, 13 subjects (81%) used the group report feature during their searching and 3 (19%) did not use it. Table 2 describes the number of subjects who used the feature for each search task.

Table 2: Usage of group report by subjects

Tasks:	T1	T2	T3	T4	T5	T6
# of Subjects who used	9	7	7	10	11	10

Another way to examine the usage of the group report feature is to see the distribution of the number of the subjects in terms of the number of tasks to find out if the subjects as a whole tended to use or not to use the feature. The results are shown in Table 3.

Table 3. Distribution of the use of group report vs. the number of tasks

# of tasks	1	2	3	4	5	6	not used at all
#of subjects	2	0	3	2	1	5	3

In addition to 3 (19%) subjects who did not use the function at all, we found that 5 (31%) subjects used the feature for only 3 or less

than 3 search tasks. Another 8 (50%) subjects, or half of the total subjects used the feature for more than 3 tasks. We were interested in finding out why they used or not used this function.

Based on the verbal protocols and the answers to our questionnaire, we found that subjects thought the group report was very useful only for difficult tasks. If the tasks were easy, they did not feel it was necessary to use it.

Those who did use the function realized that it was a new feature of this system compared to other systems and they wanted to try it out. These subjects expressed that by visiting the group report they could gain a sense of what to search, especially when they did not understand the search topic. Perhaps the major motivation for most subjects who used the feature was to share other people's queries, by which they could select appropriate search terms as well as improve the comprehension of search tasks. Essentially, a query is not only a search statement, but also represents people's search knowledge, topic knowledge and even search experience. For example, some subjects said "it gives ideas for more search terms" or "this system allows us to see as to what search query other guys used for gathering the results. This is particularly useful for difficult-to-find topics."

For those who did not use the function, they trust themselves in doing search, and they would think it was not necessary to visit other people's work report. Another reason was that the group report button in the interface is not very salient. Some subjects ignored it or forgot to use it. This is apparently a user interface design problem.

Usability evaluation: For those who used the feature, we asked them to rate some usability questions regarding the function. We found that the subjects' ratings on the usability of the group report feature are much lower than the ratings on the system's general usability. Table 4 lists the mean ratings on the five statements in the exit questionnaire.

Table 4: Usefulness ratings of the group report by statements

Statements	Mean ratings
The group report is easy to understand	3.41
I like working with the group report	3.07
I usually agree with other group members' judgment	2.37
Other people's search result have positively nfluenced my usefulness judgment	2.50
Overall, the group report feature helps me get more documents/pages for the given tasks	2.80

Overall, only two ratings are over 3 (agree). The lowest rating is 2.37, which indicates that the subjects tended not to agree with other searchers' usefulness judgments. The main reason for the poor ratings may be due to the lack of trust in the source of judgments. Bruce *et al*. (2003) found that in real world working environment, receiving information (recommendation) from other people would involve an assessment of the credibility of the people who provide the information. Unfortunately, in a collaborative filtering recommendation system, normally the recommender's credibility information is not available and the user would have difficulty in determining if the recommended items should be trusted, This would naturally lead to the fact that people would tend to rely on their own judgments, Another reason for the poor rating may be that the tasks used in the experiment were generally easy and the subjects did not feel it was needed to seek help. The user interface's usability problems, which are discussed in the following section, are another source that had a negative impact.

Usability issues identified. **In addition to the results we have discussed so far, a few usability problems in our design, particularly related to the group report function, were also identified through the evaluation. These include:**

- **Visibility of the group report function. A few subjects commented that they did not use the group report feature when they felt**

they should have used it because they forgot or ignored its existence in the system. Apparently the function's visibility in the UI should be enhanced/improved. Currently the function is neither highlighted nor in a particular position that it can easily catch the user's eyes.

- Organization of the group report. Although some subjects commented that they "can identify the content on the table," some others complained about the difficulty to identify the machine-format queries in the report. A better information organization/presentation in the report is needed.
- Navigation within the group report. One of the tasks a subject would like to do is to open and view the document when it is judged as "very useful" or "useful" by other users. An activated link to this document would be a support to such a need. Unfortunately, the current design does not implement the links. The user has to open another browser window and copy and paste the document URL in that window to view the document. This inconvenience was mentioned by a couple of subjects.
- Other problems identified are mostly related to the experimental procedure implemented in the system. For instance, access to the post-search questionnaire is not obvious, and after filling out one for a completed task, the user has to start the system over from the beginning in order to continue working on the following tasks. It would be nice to allow him/her to go directly to the next search.

Conclusion and future work

This paper describes a user interface to Web search engines, which supports sharing of search knowledge. We discuss the search knowledge required for successful searches, and strongly believe IR systems should support sharing of such knowledge.

To test the usability of the designed prototype system, we conducted a usability evaluation. In general, we found the system was effective and was acceptable by all users. All participants were able to complete the search tasks and they rated the system as generally easy to use and learn.

Our results also revealed some usability problems with the group report, the major facility for sharing of search knowledge. These user interface related usability problems certainly would have a negative impact on the users' evaluation of the system's usefulness

and the user satisfaction in general, as Swearingen and Sinha (2001) suggested. The design certainly needs to be improved in the future. We need to enhance the visibility of the function and improve the layout design of the group report. In addition, since the current system is only a prototype, not all of the functions are implemented, we plan to add in more functions, such as a search function that can find similar queries related to a topics; an automatic recommender that can suggest to the user useful documents based on other people's search results, etc.

An interesting finding in this study is that the subjects preferred sharing queries to sharing the usefulness judgments on documents. One subject commented: "[I] did not pay much attention to the judgment." They only looked at queries. The finding seems to support the idea of reusing search queries (Balfe & Smyth, 2004). It also brings up the question we have to consider when designing systems: what kind of knowledge the users are likely to share? Our results certainly raise more research questions inviting further investigation. We plan to investigate the issues through continuous experiments. In our future experiment, we will investigate the possible differences between trained search professionals (library science students) and non-professional searchers towards the use of the knowledge sharing features. We will also focus on search performance issues, to examine if the use of the knowledge sharing features would result in better search performance.

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References

Allan, J. (2004). HARD track overview in TREC 2003 high accuracy retrieval from documents. *Proceedings of The Twelfth Text Retrieval Conference*, NIST, Gaithersburg, MD, Nov. 2003. Retrieved Jun. 22, 2004, from http://trec.nist.gov/pubs/trec12/papers/HARD.OVERVIEW.pdf

Allen, B. (1991). Topic knowledge and online catalog search formulation. *Library Quarterly, 61*(2), 188-213.

Balfe, E. and Smyth, B. (2004). Query mining for community-based Web search. *Proceedings of the IEEE/WIC/ACM International Conference on Web Intelligence* (pp.594-598). IEEE/WIC/ACM 2004, Beijing, China.

Bhavnani, S. K. (2002). Domain-specific search strategies for the effective retrieval of healthcare and shopping information. *Proceedings of CHI'02* (pp. 610-611). Minneapolis, MN.

Bhavnani, S. K., Bichakjian, C. K., Johnson, T. M., Little, R. J. , Peck, F. A., Schwartz, J. L., & Strecher, V. J. (2003). Strategy hubs: Next-generation domain portals with search procedures. *Proceedings of CHI'03* (pp. 393-400). Ft. Lauderdale, FL.,.

Bruce, H., Fidel, R., Pejtersen, A.M., Dumais, S., Grudin, J., and & Poltrock, S. (2003). A comparison of the collaborative information retrieval behaviors of two design teams. *The New Review of Information Behaviour Research, 4*(1), 139 -153.

Cooper, W. S. (1988). Getting beyond Boole. *Information Processing & Management, 24*, 243-248.

Elkerton, J., & Williges, R. C. (1984). Information retrieval strategies in a file-search environment. *Human Factors, 26*(2), 171-184.

Fenichel. C. H. (1981). Online searching: Measures that discriminate among users with different types of experiences. *Journal of the American Society for Information Science, 32*, 23-32.

Frants, V. I., Shapiro, J., Taksa, I., & Voiskunskii, V. G. (1999). Boolean search: Current state and perspectives. *Journal of the American Society for Information Science,50*(1), 86-95.

Hirsh, S. G. (1997). How do children find information on different types of tasks? *Children's use of the Science Library Catalog. Library Trends, 45*(4), 725-746.

Hsieh-Yee, I. (1993). Effects of search experience and subject knowledge on the search tactics of novice and experienced searchers. *Journal of American Society for Information Science, 44*(3), 161-174.

Hust, A., Klink, S., Junker, M., & Dengel, A. (2003). Towards collaborative information retrieval: Three approaches. In J. Franke, G. Nakhaeizadeh, and I. Renz (Eds.), *Text Mining: Theoretical Aspects & Application*, Springer Verlag (pp. 97-112). New York, NY..

Kantor, P. B., Boros, E., Melamed, B., Menkov, V., Shapira, B., & Neu, D. J. (2000). Capturing human intelligence in the net. *Communications of the ACM, 43*, 112-115.

Karamuftuoglu, M. (1998). Collaborative IR: Toward a social informatics view of IR interaction", *Journal of the American Society for Information Science, 49*, 1070-1080.

Kiestra, M. D., Stokmans, M. J. W., & Kamphuis, J. (1994). End-users searching the online catalogue: the influence of domain and system knowledge on search patterns. *The Electronic Library, 12*(6), 335-343.

Linton, F. (2003). OWL: A system for the automated sharing of expertise. In M. Ackerman, V. Pipek and V. Wulf (Eds): *Sharing expertise: Beyond knowledge management* (pp.383-401). Cambridge, MA: The MIT Press,.

Marchionini, G., Dwiggins, S., Katz, A., & Lin, X. (1993). Information seeking in full-text end-user-oriented search systems: The roles of domain and search expertise. *Library and Information Science Research, 15*(1), 35-69.

Marchionini, G., Lin, X., & Dwiggins, S. (1990). Effects of search and subject expertise on information seeking in a hypertext environment. *Proceedings of the 53rd Annual Meeting of the ASIS* (pp.129-142).

Maybury, M., D'Amore, R., & House, D. (2003). Automated discovery and mapping of expertise. In M. Ackerman, V. Pipek and V. Wulf (Eds). *Sharing Expertise: Beyond Knowledge Management* (pp.359-382). Cambridge, MA: The MIT Press.

Meadow, C. T., Wang, J., & Yuan (1995). A study of user performance and attitudes with information retrieval interfaces. *Journal of the American Society for Information Science, 46*(7), 490-505.

Montaner, M., Lopez, B, & Lluis De La, J. (2003). A taxonomy of recommender agents on the Internet. *Artificial Intelligence Review, 19*, 285-330.

Newell, S. C. (1997). User models and filtering agents for improved Internet IR. *User Modeling and User-Adapted Interaction, 7*, 223-237.

Penniman, W. D. (1981). Modeling and evaluation of online user behavior. *Final report to the National Library of Medicine under extramural program grant no. NLM/EMP (1 R01 LM 03444-01)*. Dublin, OH: OCLC.

Resnick, P., & Varian, H. R. (1997). Recommender systems. *Communications of ACM, 40*, 56-58.

Romano, N. C., Roussinov, D.,,Nunamaker, J. F. ,& Chen, H. (1999). Collaborative information retrieval environment: Integration of information retrieval with group Support Systems, *Proceedings of the Thirty-second Annual Hawaii International Conference on system sciences* (pp. 1-10)..

Swearingen, K. , & Sinha, R. (2001). Beyond algorithms: An HCI perspective on recommender systems. *Proceedings of the SIGIR 2001 Workshop on Recommender Systems*. Retrieved June 12, 2005, from http://www.rashmisinha.com/articles/BeyondAlgorithms.html.

Tenopir, C. (2004) Spying on search strategies, *Library Journal, 129*, 29.

Tolle, J. E. (1983). Understanding patrons use of online catalogs: Transaction log analysis of the search method. In R. F. Vondran (Ed.), *Proceedings of the 46th annual ASIS meeting* (pp.167-171). White Plains, NY: Knowledge Industry.

Twidale, M. B., & Nichols, D. M. (1998). Designing interfaces to support collaboration in information retrieval. *Interacting with Computers, 10*, 177-93.

Twidale, M. B., Nichols, D. M., & Paice, C. D.(1997). Browsing is a collaborative process. *Information Processing & Management, 33*, 761-783.

Vakkari, P.,Pennanen, M. & Serola, S. (2002). Changes of search terms and tactics while writing a research proposal: a longitudinal case study. *Information processing & management, 39*, 445-463.

Wildemuth, B. (2004). The effects of domain knowledge on search tactic formulation. *Journal of the American Society for Information Science and Technology, 55*, 246-258.

Yimam-Seid, D., & Kobsa, A. (2003). Expert-finding systems for organizations: Problem and domain analysis and the DEMOR approach. In M. Ackerman, V. Pipek and V. Wulf (Eds): *Sharing Expertise: Beyond Knowledge Management* (pp.327-358). Cambridge, MA: The MIT Press.

Zhang, X. (2002). Collaborative relevance judgment: A group consensus method for evaluating user search performance. *Journal of the American Society for Information Science and Technology, 53*, 220-235.

Zhang, X., &, Li, Y. (2005).. An exploratory study on knowledge sharing in information retrieval. *Proceedings of the 38th Hawai'i International Conference on Systems Science*, CD/ROM, January 3-6, 2005, Big Island, Howaii.