ExplorationMap: Supporting Collaborative Exploratory Information Seeking

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ABSTRACT
Exploratory information seeking in a knowledge domain, especially in an interdisciplinary area, with the purpose of learning and getting a sense of the domain is a challenge that new researchers are constantly facing. To address this challenge, we suggest a new visualization-based approach for collaborative exploratory information seeking. First, we introduce ExplorationMap, which is a node-link graph visualization of the pathways explored by the user. Then, we discuss how the ExplorationMap can establish the ground for collaboration between researchers, while exploring a knowledge domain. We believe that ExplorationMap can facilitate sensemaking processes as well as learning through exploratory search, all of which we will verify in the next steps.

Author Keywords
Exploratory search, collaborative information seeking, exploration, sensemaking.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

Exploratory information seeking includes activities such as information look-up, learning, and investigation that can overlap in time [8]. Different forms of collaboration have been proved to facilitate and make each of these activities more effective and more efficient by employing varieties of expertise, knowledge, and perspectives. More knowledgeable information seekers can achieve meaningful learning [2] easier than less knowledgeable ones in an exploratory search process because of the more developed schemas, which enable them to find the associations between 'what exists' in their schemas and 'what they find' more efficiently, whereas less knowledgeable searchers are constantly suffering from lacking sufficient domain knowledge in their explorations. This fact justifies this famous frequent demand of a new researcher in a field to the expert researchers: "tell me what I don't know I need to know". The suggested approach aims to support and facilitate such collaboration between these two groups, which can be very beneficial for novice researchers. Also, for motivating the experts to participate in such a collaborative search process, we should consider reducing the participation cost, which is a determining factor.

This collaborative search can also be considered as a social search: "a range of social interactions facilitating information seeking and sensemaking tasks" [5]. The social interactions before, during, and after the search episodes have been investigated by Evan and Chi; their results showed that social interactions before the search will give the searchers some clarifications and guidelines on the tasks, advice, suggestions, keywords, URLs, and etc [5]. All of these artifacts, results of the social interactions before the search episode, will also be useful *during* the exploratory search, which is inherently a long-term and iterative process. Therefore, given the fact that the searcher's interests and needs are evolving and being shaped during an exploratory search process, we aim to support all the *before* the search social interactions during the exploratory search.

In this paper, we describe the design of a system for supporting collaborative exploratory search. The means of the collaboration is ExplorationMap, a visualization of the information seeker's path. The collaboration can be between a domain A expert/a domain B expert or a domain A expert/a domain A novice based on the roles suggested by [7]. Experts can bridge the gaps that novices are constantly facing, between what they know and what they seek for. An information seeker can rely on information scent provided by various cues on his ExplorationMap that have been suggested by the experts. These cues can be anything such as a new relationship between two concepts, a tag, a new journal, and etc. This kind of collaboration is of crucial importance in interdisciplinary research areas, in which the searchers should have a broad knowledge of the domain not to miss the relationships in their exploratory search. Considering the classification of computer-supported collaboration in information seeking suggested by [7], this work falls into the category of explicit and both synchronous and asynchronous collaborations.

EXPLORATIONMAP: BUILDING FOUNDATIONS FOR COLLABORATION

Keeping the history of explorations is a critical consideration in designing exploratory search support systems, as usually information seekers need to go back and forth between their findings to get a sense of the domain under exploration. We suggest recording the pathways, which have been traversed by the user, in ExplorationMap in the form of a node-link graph, in which a node is a representative of a visited resource such as a web page or a paper and links show the user's path. If visiting node 'A' introduces node 'B' to the user and the user continues his journey from 'A' to 'B', there will be a link from 'A' to 'B' in the ExplorationMap. For example, a link can be a representative of a citation, or a new search session with additional keywords that have been found in the source node. Visiting a page, whether it's a new article or a webpage, can introduce new references, keywords, authors, journals, and conferences, all of which can shape the next steps in the exploration and be the causes of visiting the next series of pages. In this paper, we will consider the following simplified preliminary design (Figure 1) for the ExplorationMap to focus on the idea of collaborative information seeking.

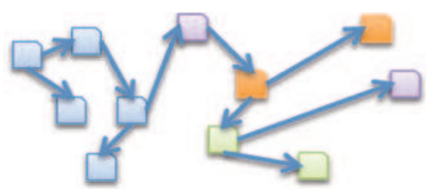

Figure 1: An example of node-link exploration map. Each node represents the visited resource and link represent the user's path between resources

The ExplorationMap can help the searcher to explore and make sense of the domain more effectively and efficiently for at least two reasons. First, it will facilitate sensemaking [6] of the domain under exploration by providing overview of the traversed pathways and unveiling the semantic connections between the explored concepts through externalizing the internal connections in the mind. Secondly, we believe that sharing the ExplorationMap will be much more effective in collaborative search than sharing the information need, which is inherently unclear in an exploratory search. The ExplorationMap can provide more contexts around the unclear information need that can help collaborators to gain a better understanding of the user's information need and to establish the common ground for achieving more effective collaboration, however, in the systems supporting co-located collaborative search such as [1], common ground can be achieved much easier through face-to-face communications.

Design Goal & System Features

Our primary goal in designing ExplorationMap is to facilitate and support meaningful learning in exploratory search. We plan to achieve this goal in two complementary ways; first, through designing an intuitive visualization of the explored path and secondly, through sharing this visualization with the relevant people to the explored domain and making the exploratory search more effective through collaboration. In order to support learning in collaborative exploratory search, the collaboration needs to be developed in the background not to interfere with the primary task and to keep the information seeker in the flow [4].

The following features have been considered in designing the ExplorationMap:

ExplorationMap is automatically generated while the user is exploring

In order to let the user become immersed in his exploration, the ExplorationMap is automatically generated without requiring the involvement of the user while providing awareness of the path under exploration.

User should be able to reflect on his experiences and findings during the path he has taken

This reflection can be as simple as marking the explored nodes as relevant or irrelevant, or more costly actions such as annotating the nodes with some navigational advices to enable the system to suggest their findings to other users with similar interests and goals. As users move forward in their explorations, they learn and make sense of the connections between resources; this feature enables the users to reflect on their experience of going through a specific pathway by providing additional information scent (cue) on their ExplorationMaps for their future explorations or to help other users in that domain through sharing and enabling the integration of ExplorationMaps.

Visualizing the evolution of user's interest during the search

It is important for the user to be aware of the evolution happening to his interests during the search. This can be done using a dynamic tag cloud to visualize the most frequent keywords in the explored resources over time that reflect the current focus and interest of the user.

Providing preview of the nodes on the path

Preview of the nodes shows the least information for recognizing the node without going back to it. This will enable the users to navigate in their ExplorationMap more easily for refreshing the memory or annotating without having to re-explore some of the resources.

RECOMMENDATIONS ON THE EXPLORATION MAP

Analyzing the user's pathways and extracting the authors' names in the already traversed nodes will generate a sorted list of authors, whose publications have been visited. The editable ExplorationMap of the searcher will be shared with the key authors in the list, who can provide some navigational advices for the novice by adding related keywords or tags, unveiling the relationships between some of the existing concepts in the map, and introducing potentially interesting unexplored areas for the user. Similar suggestion-based approaches for encouraging the contribution of experts have been applied on some of the online communities such as Wikipedia [3].

Because the system tries to involve experts for providing these information scents, we can expect them to be of high quality [10]. The high quality of recommendations is one of the advantages of such systems over social bookmarking applications. Although social tagging systems can provide both intentional and inferred navigational advices, most of the social tagging systems suffer from the contributions' quality [9].

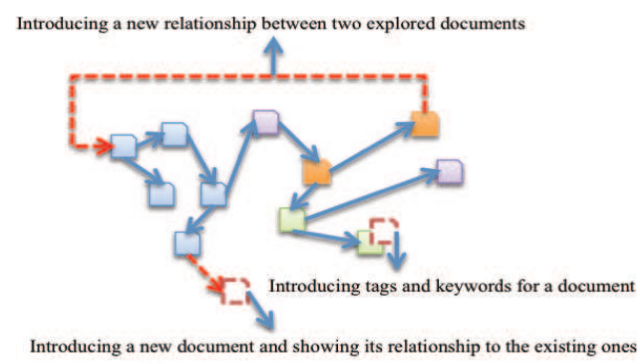

Figure 2: Collaborators' recommendations are shown in the ExplorationMap by the red dotted lines. The recommendations can have different forms including introduction of a new relationship, new resource, tags and keywords. The color of the nodes shows the associated domain with a resource. For example, orange nodes are the visited articles from domain A, blue ones from domain B, and so on.

Once the domain expert augments the user's ExplorationMap, the user can see the recommendations on his ExplorationMap (Figure 2). The experts' recommendations will be associated with the search behavior for future use in order to avoid sending repetitive requests to experts.

CONCLUSION

Exploratory information seeking can be considered as an effective learning activity that the lack of support tools can transform it into a frustrating activity. Information seeking in an interdisciplinary area is an example of such activity that needs the appropriate support to be effective. For achieving our goal of supporting learning in exploratory search, we introduced the ExplorationMap, which is a node-link graph that shows the pathways explored by the user. We believe this ExplorationMap will help us achieve our goal in two ways: first, by facilitating the sensemaking processes with having the externalized overview of the process and secondly, by providing the foundations for collaborative search with two different purposes: taking advantage of experts' knowledge in the domain under explorations and accelerating other users' search with similar information needs.

ACKNOWLEDGMENTS

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Leveraging Trust Relationships in Digital Backchannel Communications

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Abstract
Discussions during lecture can clarify lecture points for audience members and help them deepen their understanding. However, the fast-pace of lectures and the large number of attendees can make these discussions impossible. Although digital backchannels have been used to address this problem, they present some drawbacks such as increasing distractions and not providing valuable information. We suggest incorporating audience members' levels of trust in the knowledge of other members into the design of backchannel communication systems. Based on this approach, we present methods and design considerations to overcome the aforementioned drawbacks of the previous backchannel communication systems.

Keywords
Backchannel, Trust-network, Social filtering, Classroom communication, Back channel.

ACM Classification Keywords
H.5.3 Group and Organization Interfaces: Computer-Supported Cooperative Work.

General Terms
Design, Human Factors

Introduction

Discussions among audience members during a lecture is a method of cooperative learning that can increase breadth and depth of the learning experience and is considered as an active learning strategy. Audience-initiated interactions in large lecture rooms can be impeded by various factors such as fast pace of lecture, weak communication skills, lack of self-confidence, and fear of asking unintelligent questions.

According to the constructivist learning theory, learning is an active process in which learners construct new ideas and clarify concepts based on their experiences and current knowledge through discussions by selecting and transforming information [10]. Computer-supported backchannels are designed to facilitate audience discussions. They allow attendees to ask their questions and start discussions to clarify or complement the front-channel (instructor's presentation) without interrupting it. However, the negative effects of backchannels such as distracting audience and creating off-topic discussions are not negligible [4].

In this paper, we present two methods for incorporating audience members' trust in each others' knowledge (just *trust* from now on) into the design of systems supporting backchannel communications. We explain the implementation of a proof of concept prototype. Finally, we analyze the social and cognitive aspects of the two approaches to incorporating trust. The analysis is informed by results of a pilot study obtained through content analysis of backchannel discussions and follow-up interviews.

Related Works

Digital backchannels have been used in meetings [14], conferences [6,8] and classrooms [15]. Backchan.nl is a web-based system designed for academic conferences that helps presenters to manage audience questions [6]. Backchan.nl is a hybrid of back and front channels, since it provides a ranked list of audience comments and questions based on the audience votes. A comprehensive study was conducted at UC Berkeley with a public chat environment in a graduate classroom to understand the effects of using backchannels in long term [15]. Their study reported both off-topic and constructive discussions in the backchannel communications. In another studyat UC San Diego, students used ActiveClass [11] as their classroom backchannel to anonymously ask questions, answer the polls, and give feedback to the instructor. Earlier efforts in this area are covered in [15] and a review on various backchannel functions and possible interactions is available in [3].

Previous studies have shown the negative effects of using backchannel communications on audience's attention [4,15]. However, backchannels may help audience to engage in the topic and not to lose track of the presentation[11,13,15]. All of the previous backchannel were in the form of public [6,11,15] or private [14] chat rooms, each of which had different problems such as increasing students' cognitive load (mainly in public channels) and not providing helpful information to the information seekers (mainly in private channels).

Leveraging trust in backchannels

Trust-networks are social networks in which nodes represent users and directed edges represent trust relationships between users. Based on the existing relationships in a trust-network, the trust level for non-existent relationships can be inferred using trust inference algorithms [1,5,9]. Trust-networks have been employed in several areas such as recommender systems [5], and collaborative search [2]. The concept of trust maps to various constructs such as confidence, reputation, credibility and reliability in different domains. For example, in trust-based recommender systems, trust can be interpreted as confidence in taste. We present two methods for incorporating trust into backchannel communications. In the first method, trust in each other's knowledge is used for devising a routing mechanism for outgoing messages. The second method applies trust as a filter on incoming messages.

Routing outgoing messages
To meet our information needs in everyday situations, we usually start with using the most available resources such as the Internet and our friends, whom we trust in their knowledge relevant to our need. Trust inference algorithms can be used to extend the limited list of helpful friends and determine the receivers of questions in a backchannel. Trust, in this context, can be interpreted as a user's trust in others' knowledge and helpfulness. The group of first-level trustees can be augmented using a trust inference algorithm. We use the concept of "trustee" instead of friend, because the nature of discussions are supposedly about the lecture topics and people tend to ask from their more knowledgeable and helpful peers.

Augmenting a user's group of trustees and facilitating the communication with people at different levels of his trust-network increases the availability of information. One of the main goals of using backchannels is to

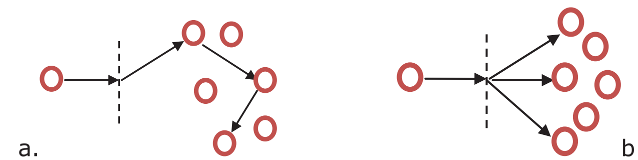

Figure 1. Trust-based message routing

a. Incremental group formation

b. Threshold-based group formation

decrease the intrinsic cognitive load of lecture materials caused either by their complexity or pace of the lecture; therefore, the accessibility of others' knowledge is a key factor in backchannels' effectiveness. Digital backchannels can be designed so that the users do not have to ask questions from a specific person; instead, they can send the question to their trust-network which will be routed through the network until someone can respond, or help the discussion (Fig. 1.a). This approach can substantially affect the audience discussions by providing opportunities for new and hard to initiate communications. The backchannel becomes a social catalyst that can be particularly valuable in conferences. However, the second approach (discussed later) can be more suitable when backchannel discussions are meant to be community discussions and the goal is to engage with a group of users.

We designed and developed a prototype of such backchannel to understand the possible implications of the design. In this prototype, a user can express an opinion or ask a question from his trust-network. Then, the message is routed to the first (most trusted) available trustee and if the receiver is unable to help (which can be determined by either party) the message will be passed to the next trustee and so on. The pilot study was conducted with 5 students in two 45-minute lectures, followed by interviews, to compare this design with a private backchannel (i.e. a private chat room).

The Trust-enhanced Backchannel Prototype
The goal of designing the proof-of-concept prototype was primarily enabling an exploratory study. The design decisions were made based on the basic functional and non-functional requirements, usability heuristics, and the available literature on designing digital backchannels. The prototype's interface consists of three tabs: trust management tab, history tab, and backchannel tab. In the trust management tab, students can express their trust to each other using a 5-star rating widget and see their explicit and inferred trust relations (Fig. 2). Backchannel-tab shows the ongoing discussions (chat-boxes), and has a button for initiating a discussion. The backchannel discussions are not anonymous. Finally, the history tab allows reviewing the previous discussions. A chat-box has three possible states. *Initial* state is similar to a plain private chat-box. *Asking* state (Fig. 3.b) includes an "*Ask someone else*" button to be used when the current responder's answer is not sufficient to address the information need. Finally, *answering* state (Fig. 3.a.) includes "*Pass it*" button to be used by the responder when he cannot help the discussion. Both "*Ask someone else*" and "*Pass it*" buttons cause the system

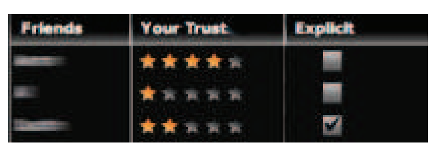

Figure 2. Trust management interface

to search for the next trustee in the asker's trust-network.

Communication multiplicity
In this approach, outgoing messages are routed to the trustees who possibly may provide a helpful response. The number of trustees who receive the message and the level of their trustworthiness is an important factor that needs careful consideration. One option is to send the message to all of the people with a certain level of trustworthiness (Fig. 1.b) and initiate a group discussion on a topic. This method may lead to more discussions, but it may distract all of the participants in the discussion from the front channel. The alternative is to send the message to the peers, one by one based on their trustworthiness until the information need is satisfied (Fig. 1.a). The number of people involved in the discussion increases until the group solves the problem. This may impose the extraneous cognitive load on as few people as possible.

Transparency, Predictability and Controllability
Transparency and predictability of the trust inference algorithm was one of the issues we confronted in the pilot study. Three of the participants preferred to know who will respond them before asking a question and they wanted to know how exactly the trust inference algorithm is working. Another issue that arose during

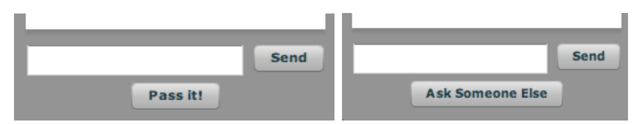

Figure 3. Different chat-box states

a. Responder's view b. Asker's view

the study was that students liked to keep each other responsible for answering their questions; because they were concerned about others using "*Pass it*" button when they hesitate to help. However, they liked to be able to use it as responders, when they are not sure about their response.

The design should deal with a trade-off between privacy and transparency, since unveiling the inference process requires exposing other users' relationships. One of the users mentioned that "knowing who is going to answer, informs the choices about what kind of language to use". Obtaining approval from the asker before sending the question to a new person could increase the controllability of the system. However, since we were in the exploratory phase of this research, we wanted to see users' reactions when receiving responses from people they are not friends with. Content analysis of the backchannel discussions showed that all of the users were able to satisfy their information needs regardless of who had the useful information, and one of the users mentioned that he liked "contacting someone you would not usually ask". Based on the interviews, the quality of answers in the trust-based backchannel were as good as in private backchannel and most of the users preferred to have the trust-enhanced backchannel as an augmentation to instant messaging (private channel). A larger study is required to conclusively evaluate the effectiveness of this approach in reducing distractions and increasing the availability of information.

Filtering incoming messages

The second approach to leveraging trust relationships in backchannels is using them as information filter on incoming messages. Social relationships have been used in various information retrieval systems for filtering information [7,12]. Users need to be frugal in spending cognitive resources, mainly attention, on the backchannel communications not to lose track of the primary flow of information. Therefore, trust can play the role of an information filter to engage users only in the discussions that are worth paying attention.

One of the major usability issues of public backchannels is the relatively high frequency of messages, which may interrupt all of the users regardless of the usefulness of the information to them. A trust-based filter on the incoming messages can be used to deal with this issue. Users may decide to receive only messages from the users who are of a certain level of trustworthiness (as in Fig. 3), or in a more complex interface, the visual saliency of the backchannel messages can be adjusted based on the trustworthiness of their senders. In this approach trust to a person can be defined as the perceived probability of him sending useful or interesting messages to the backchannel.

This can be a way of reducing the number of interruptions and decreasing the extraneous cognitive load. Moreover, it helps preventing valuable messages going unnoticed, which is likely in public chat rooms due to the noise (i.e. non-useful messages). People may have different purposes for attending a lecture and messages that are less interesting for a specific attendee can be of importance to others. Therefore, determining the noise should be based on the personal trust-network rather than public measures such as reputation. The major drawback of this approach is that when someone hopes to get help from the more knowledgeable users, his message may go unnoticed, because they have not expressed their trust to him.

Conclusion

The proposed mechanisms are just starting points for investigating the opportunities for designing socially-aware digital backchannels. We designed a prototype of a trust-based backchannel, and conducted a pilot study to understand the implications of leveraging trust relationships in digital backchannels. By incorporating social relationships in design of digital backchannels, we can overcome some of the drawbacks of the public and private backchannels. The proposed approaches reduce the possibility of distraction, which was the major drawback of public backchannels. They also improve the accessibility of information in comparison with private backchannels. These enhancements can help resolving the trade-offs of using backchannels [6] in lecture-based learning environments.

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