SocialSearchBrowser: A novel mobile search and information discover tool

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ABSTRACT
The mobile Internet offers anytime, anywhere access to a wealth of information to billions of users across the globe. However, the mobile Internet represents a challenging information access platform due to the inherent limitations of mobile environments, limitations that go beyond simple screen size and network issues. Mobile users often have information needs which are impacted by contexts such as location and time. Furthermore, human beings are social creatures that often seek out new strategies for sharing knowledge and information in mobile settings. To investigate the social aspect of mobile search, we have developed SocialSearch-Browser (SSB), a novel proof-of-concept interface that incorporates social networking capabilities with key mobile contexts to improve the search and information discovery experience of mobile users. In this paper, we present the results of an exploratory field study of SSB and outline key implications for the design of next generation mobile information access services.

Author Keywords
Mobile search, social search, social networks, location-based services, context, field study, user evaluation

ACM Classification Keywords
H.5.2 Information interfaces and presentation (e.g., HCI): User Interface, H.3.3 Information Storage and Retrieval: Information Search and Retrieval.

INTRODUCTION
There are more mobile phones in the world than personal computers. They allow communication across remote locations and ubiquitous access to a wealth of information sources. Yet, most of the information retrieval systems that are available within the mobile space today are simple adaptations of their desktop counterparts and as such are not well-suited to handle the complexities of mobile contexts. In particular, geographical information is intimately related to mobile devices, as they are typically carried by their owners in their daily lives. Contextual information of this nature is too fined grained and too dynamic to be captured by web technologies. Often, we seek and share local information through other communication channels and word-of-mouth appears to be the most reliable and efficient communication medium in certain information seeking tasks [28]. For instance, standard search tools have difficulties providing answers to questions such as finding information about an upcoming friends birthday or what is the most populated club in a city after a major sporting event.

Furthermore, humans are social beings who often seek new and improved ways of sharing information with their peers. In the last few years, several research projects have attempted to exploit the social dimension of search by designing interfaces that allow users to collaboratively help each other in finding the information they need [13, 22, 25]. However, these prototypes were designed with the desktop experience in mind. Conversely, prototypes that were built to improve mobile search did not exploit the social dimension of information seeking [16, 18].

In this regard, we are interested in understanding whether people's information needs while on-the-go could be addressed by providing a readily available connection to a user's social network. We believe that friends and family, who are trusted information sources, are likely to be able to draw on their experiences to provide interesting, valuable and relevant answers to the user's queries while on-the-go [15].

To explore this research space, we have developed **SocialSearchBrowser** (SSB in short), a proof-of-concept, map-based mobile search prototype designed to enhance the search and information discovery experience of mobile users by allowing them to (1) see the queries and interactions of peers and to (2) pose queries of their own (see detailed description in Section "SSB prototype"). SSB gives users the ability to connect with friends or family members while on-the-go and ask them questions. Interactions are handled on a rich map-based interface, which enables the use of deictic gestures between the remote peers [6]. Furthermore, SSB provides novel methods for filtering the queries displayed based on the level of the friendship among users.

SSB was deployed in a live field study in Ireland during the first week of April 2009. Sixteen participants tested the application and generated approximately 300 messages. Their interactions with the application were logged and time stamped in the SSB server which allowed objective analysis of their usage of the system. These measures were complemented by a post-study survey allowing us to elicit subjective information regarding the experiences of participants and based on these results we were able to draw a number of

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important implications for the design of social mobile applications of this nature.

The rest of this paper is organized as follows: Firstly, we summarize related studies that inspired and guided our approach and methodology. Secondly, we describe the SSB prototype. Next, we outline the methodology that we employed to conduct the field study. Then, we report the main results of the study, starting with the objective measures of the users' interaction with the system, followed by key findings of the surveys. Finally, we describe the implications for design that emerged from this research.

RELATED WORK

Our current work is relevant to a variety of research areas including: exploratory search, mobile search, social search and location-based annotation services. In this section we highlight key papers in each of these related areas.

Exploratory Search

In standard Web search, users submit a query via a search box and view a textual list of results. More recently, a new class of search has emerged, called *exploratory search* [29], which supports the exploration and discovery of information through both querying and browsing strategies. In that regard, Marchionini [21] identified three types of search activities: (1) lookup, (2) learn and (3) investigate. Lookup searches can be thought of as traditional search, while learn and investigate searches relate to discovery-oriented tasks.

In recent years, a few desktop exploratory search systems have been proposed in the literature. Yee *et al.* [30] presented an alternative interface for exploring large collections of images using hierarchical faceted metadata and dynamically generated query previews. Similarly, Alonso *et al.* [1] described an interface that utilizes timeline data to enable effective presentation and navigation of search results. Finally, Tvaroek & Bielikov [23] proposed a personalized faceted browser that facilitates exploratory search by providing users with an integrated search and navigation interface that combines full text, faceted, content-based and collaborative search. However, these prototypes were not built specifically for mobile devices, nor the user experience of interacting with them adapted to location-specific information. This particular aspect was explored by the projects described in the next section.

Mobile Search

Another area of research related to this paper concerns innovative approaches to mobile search. **FaThumb** [18] is a mobile search application designed for efficiently navigating through large data sets on mobile devices providing a more efficient means of mobile information access. A user evaluation of FaThumb demonstrated how the facet-based navigation is faster for less specific queries. Heimonen and Käki [16] examined the use of search result categorization to improve presentation on mobile devices through an interface called **Mobile Findex**.

The **Questions not Answers** (**QnA**) prototype [17] represents an interesting alternative to traditional mobile search. QnA allows users to access previous queries posted from the user's current location by means of a map-based interface, providing users with an *enriched sense of place*. By clicking on the queries, users can execute the displayed search. However, users cannot interact with the author of a particular query. In a live user study [2], users found the interface to be useful and they enjoyed the proactive display the interface enabled. However, there is a social component to search that these prototypes were missing and that was addressed by other projects described in the next section.

Social Dimensions of Search

More recently, researchers are investigating the social side to search. For example, Collaborative Web Search (CWS) involves utilizing the search histories (*i.e.*, queries and result-selections) of communities of like-minded individuals. In [12], Freyne *et al.* looked at integrating CWS with social browsing in order to produce an integrated social information access service. Preliminary results from a live user trial indicated that the use of social cues helps users to access relevant information in an easy and efficient manner.

Alternative approaches involve exploiting Web 2.0 technologies, specifically Web annotations, to improve Web search. The basic premise is that by allowing users to annotate search results and share these annotations with others, the search experience may be improved. Boa *et al.* [3] proposed two novel algorithms to explore the role of social annotations on similarity ranking and static ranking respectively.

Another related area of interest is *social search*. Social search in this context involves exploiting different forms of human judgements, ratings and interactions to improve the overall search experience. There have been a number of social search services developed recently, including **Stumbleupon**[1], **Wikia Search**[2] and Microsoft's **U Rank**[3].

The prototypes listed above employ an extended definition of the "social context" of users as in these cases the social context also includes *strangers* and relates more to the definition of *social navigation* [11]. In the work presented in this paper, *social* refers to the group of friends or contacts with which we maintain communication through social networks.

Most relevant to our current work is the use of social networks to enhance search results and online interactions. Mislove *et al.* presented **PeerSpective** [22], an experimental prototype which exploits both the hyperlinks of the Web and the social links within communities of users to inform a new search result ranking approach. An evaluation of the PeerSpective search engine showed that it performs well in terms of disambiguation, ranking and serendipity of search results.

Pujol & Rodriguez [25] presented **Porqpine**, a distributed social search engine which crawls, indexes and ranks content implicitly and collaboratively as users browse and search. Porqpine utilizes multiple social network sources such as Facebook, twitter and email contacts.

Although related to our proposal, these prototypes were de-

[1] See `http://www.stumbleupon.com`, last retrieved September 2009.

[2] See `http://search.wikia.com`, last retrieved September 2009.

[3] See `http://research.microsoft.com/projects/urank/`, last retrieved September 2009.

Figure 1. Screenshots of the SocialSearchBrowser (SSB) Application: *(left)* The map screen is the main screen of the SSB application. Queries are overlaid on a Google maps visualization (own queries are show with a green semi-transparent background) and three drop down menus that allow the user to filter the displayed queries; *(center)* The query detail screen shows three categories of answers: (1) answers by other users, (2) results from Google local search and (3) results from Eventful API; *(right)* When a query is answered, the user can optionally add a location.

signed for desktop-based generic searches and not customized for mobile location-based searches, which is our objective.

Location-based social search

Lastly, it is worth mentioning several projects that aim to connect electronic information, (*e.g.*, a Wikipedia article describing a monument), to the physical location to which the information refers. The most relevant projects in this domain have enabled users to generate textual content in digitial form linked to a physical location, such as **GeoNotes** [24], **ActiveCampus** [14], **E-graffiti** [5], and **UrbanTapestries** [19]. All these interfaces allow users to express opinions, preferences, recommendations, *and questions* — all connected to a physical place.

More recently, commercial applications appeared on the market. For example, **Loopt**[4] or **BrightKite**[5]) enable social serendipitous encounters and keeping track of what your friends are up to. Other applications allow people to share recommendations on restaurants or other commercial activities (*e.g.*, **Yelp**[6], **FoodBuzz**[7], or **Tabelog**[8]). Google and Yahoo also provide generic location sharing services (*e.g.*, **Latitude**[9] or **Fireeagle**[10]).

Most relevant to our work is the prototype developed by Bilandzic *et al.* [4] called **CityFlocks** which allows users visiting a new city to pose questions —via phone calls and SMS, to local citizens. The trial of the application was successful although users reported misgivings in posing questions to complete strangers. We believe that an important dimension of information seeking is the *level of trust* that is associated to the information provider. Hence, the importance of leveraging social networks in the context of social search.

Our Proposal

The work presented in this paper builds upon earlier work presented in [7, 9]. The SSB prototype is similar in nature to the QnA prototype. The QnA system tags queries with a location. These queries are displayed on a map-based interface enabling users to visualize the search space. The QnA prototype does not, however, provide any means for a user to filter queries, other than by location. Given that the volume of queries at specific locations is likely to be high and there is no means to filter queries, the QnA prototype raises a new interface / presentation challenge. In our prototype, we address this issue by offering the user three types of filters. Additionally, although QnA pioneered the proactive display of queries on a map, the application did not allow users to issue their own queries nor to communicate with the author(s) who generated the queries being displayed. Thus, the realism of their user study is limited in some regards. The proposed SSB prototype allows its users to add and respond to queries, and to interact with other users.

Additionally, our work is related to the CityFlocks approach, although the SSB prototype focuses the interaction to the group of peers that can provide *trusted* information to the user [15]. In this regard, a key contribution of our work is to explore the *social side* to mobile search, not only through a social query filter, but also by studying mobile search mediated interactions with peers (*e.g.,* members of the user's social network).

In summary our research questions can be stated as follows: *RQ1: How do mobile users interact with proactive mobile information access applications?*, and *RQ2: What are the implications of these types of applications on the design of mobile search services?*

[4] See `http://loopt.com`, last retrieved Sept 2009.
[5] See `http://brightkite.com/`, last retrieved Sept 2009.
[6] See `http://www.yelp.com/`, last retrieved Sept 2009.
[7] See `http://www.foodbuzz.com/`, last retrieved Sept 2009.
[8] See `http://tabelog.com/`, last retrieved Sept 2009.
[9] See `www.google.com/latitude`, last retrieved Sept 2009.
[10] See `http://fireeagle.yahoo.net/`, last retrieved Sept 2009.

SSB PROTOTYPE

SSB is designed to enhance information search and discovery by displaying what other users have been searching for on an interactive map-based interface. The software architecture of SSB consists of three components: (1) an iPhone application that allows users to browse, answer and add queries; (2) a Facebook application that allows a given user's social network to browse queries and add new answers to those queries; and (3) a server that synchronizes and stores all queries in the SSB database [11]. The server feeds applications (1) and (2) with an up-to-date list of all queries and answers. When a new query is issued by a user, the server submits the query to the Google Local Search API and the Eventful API for a set of possible search results[12]. The server also comprises an SMS notification facility that informs members of the appropriate social network about new queries and new human generated answers. In addition, the server logs all the interactions between the user and the GUI of the iPhone application for off-line analysis of user behaviour.

Mobile application

The main interface of the SSB mobile application consists of a Google Maps visualization of the user's current location (Figure 1, left) with overlaid queries. This map-based interface provides users with a *sense of place* at a glance by allowing them to visualize the kind of queries that other users have issued while they were at the same location. The map indicates the user's current location by a blue circle. A tiny red circle positioned at the center of the map marks the location that new queries will be associated with. As users pan or zoom within the map, the set of visible queries is updated.

An *icon* is assigned to each query to indicate what kind of information is available about the query. This icon is displayed to the left of the query text (long query texts are truncated on the map interface). A small magnifying glass icon is assigned to a query that does not result in the selection of any search result[13] (Figure 2a). A query that resulted in the selection of at least one search result is identified by the globe icon (Figure 2b). If a query has been answered by a user of the SSB application, the associated icon is augmented with a small image that depicts a user (Figure 2c and d).

Figure 2. Located at the left of the query text, icons indicate the kind of answers that exist for the query: (a) queries without any human answers and or search result selections (i.e. hits), (b) queries with at least one search result selection, (c) queries with human answers and (d) queries with both human answers and result selections.

A semi-transparent background colour conveys the *origin* of the query: queries are either issued by the user him/herself (*green background*), his/her friends (*red background*) or other people (*blue background*). Furthermore, the size of the query icon reflects the *popularity* of a query based on the number of answers that the query has received and the number of times the details of a query have been accessed by the users (Figure 1, left).

Interactive filters

Three filters positioned above the map allow the user to control the queries that are displayed (Figure 1, left). The filters may be used to reduce the number of queries on a crowded map or to focus on queries that fulfill specific criteria.

The *time* filter enables a form of temporal visualisation of queries. For example, users can view queries that have been submitted in the last two of hours (setting *now*), in the last 24 hours (*today*), the last week, etc.

A similar principle applies to the *friendship* filter. This filter allows users to show queries submitted by *everyone* or only by *friends*. This social filter has several degrees of 'levels of friendship'. The premise behind this filter is that in some situations, users might prefer to see queries that have been generated by friends. The level of friendship is determined by SSB as number of wall posts, tags and comments that have been exchanged between the two peers within Facebook[14].

Finally, the *similarity* filter allows users to limit the displayed queries to those that are similar to queries that have been previously entered by the user him/herself. For a given user and a given query, SSB calculates the *similarity* as the number of words that match between the query in question and all other queries issued by the user in question[15]. Queries are displayed only if the number of matching words is equal or greater than the threshold value that is set through the similarity filter.

Query details and answers

Double-tapping on a query brings the user to the query details (Figure 1, center). The query details screen consists of 4 components:

1. *Full query details*: Showing the complete query string, the timestamp when the query was issued and the name of the user who issued the query only if this user is a *friend* of the current user.

2. *Answers*: A list of all answers that have been submitted by other users. Answers can be submitted by users via the mobile application or via the Facebook application (see below).

3. *Local search results*: A list of localized search results extracted from Google's local search service[16].

4. *Event search results*: A list of related events extracted from the Eventful API[17].

[11] We use Tomcat for the server requirements of the application and all data is stored in a MySQL database.

[12] We define search results returned by the Google Local Search API and the Eventful API as *machine generated answers*, while answers submitted by other users or friends within a given social network are defined as *human generated answers*

[13] A *search result* in this case is defined as one of the results returned by either the Google Local Search API or the Eventful API.

[14] In the current implementation, we use Facebook as a source of social network information, however, other online social network information could also be exploited. Upon registration, users grant SSB access to their social network. This information is stored in SSB's server and the user's original social network is never accessed again.

[15] The similarity is calculated after stemming and stopword removal

[16] http://code.google.com/apis/ajaxsearch/local.html

[17] http://eventful.com/

Tapping on the "plus" icon beside any of the individual query details expands additional information about the associated answer, local search result or event search result. These details include a map with a location, phone numbers and a "more info" link to an external webpage (Figure 1, right).

Facebook application

Queries that have been submitted via the mobile application can also be answered by the user's friends through the SSB Facebook application. The Facebook application lists all queries that have been submitted by any friend together with the name of the user who issued the query and the timestamp and location of the query (Figure 3).

Clicking on a query opens a detailed information page (See Figure 3) that shows additional query details and a Google map of the location of the query. Additionally, it displays a list of all the answers submitted for the query and an input form for entering new answers. Facebook users can also add a location to their answer, generating what we call a *geo-answer* [6], simply by clicking on the point of the map where the resource was located. Therefore, Facebook users are able to see what queries their friends have executed while on-the-go, where and when their friends executed these queries and any answers provided to these queries.

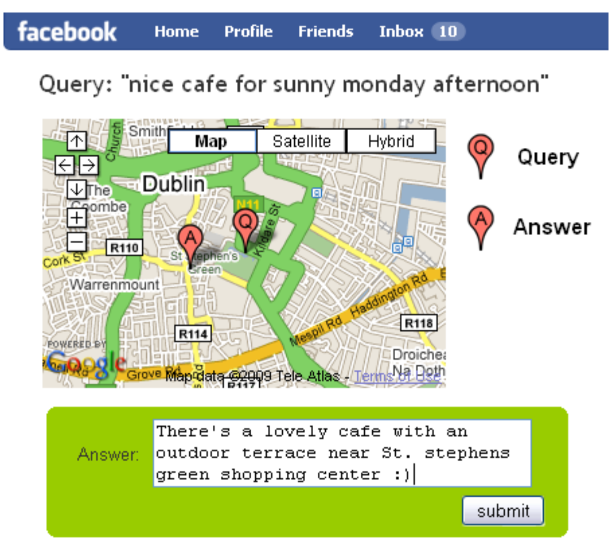

Figure 3. A friend uses the Facebook application to submit the answer to a query and to add a location to the answer.

EVALUATION OF THE SSB PROTOTYPE

Understanding the impact of applications such as SSB on users' behavior is challenging because these applications support novel types of mobile experiences that lie beyond the scope of established practices and social conventions. Therefore, we deployed a *breaching experiment*, as suggested by Crabtree [10]. In a breaching experiment, new technologies are deployed in the wild, allowing them to provoke new practices and reveal contingencies between activities and technological interactions.

Hence, we carried out an exploratory field study involving 16 participants in Dublin, Ireland. The goal of our study was to investigate how mobile users react to this type of application and to highlight key learning outcomes and implications for the design of future mobile information access services.

Participants

Due to our design choices, participants were required to own an iPhone and be active Facebook users. We recruited participants using an online questionnaire which we advertised in various Internet boards and mailing lists within Ireland. From a pool of more than 100 respondents, we selected a subset that matched our requirements. Participants were informed that a small incentive — in the form of a gift voucher — would be provided for taking part in the study and that they would be rewarded for involving their friends in the study. This additional incentive provided a motivation to have friends installing the Facebook application.

In total, 16 participants took part in the study (14 male and 2 female) who ranged in age between 18 and 54, with an average age of 29 (stdev 8.8). The participants lived in various counties in Ireland and had a diverse set of occupations, including undergraduate students, a PhD student, a musician, a nurse, a factory coordinator, a car salesperson, a porter and a few IT/Technical support specialists.

Most of the participants owned the 3G version of the iPhone ($> 87\%$). Most users ($> 60\%$) had their Facebook account for more than a year. The vast majority of participants accessed their Facebook accounts at least once per day ($> 87\%$) and the majority of them ($> 87\%$) stated that Facebook is part of their daily routine. All but one participants have more than 10 Facebook friends (median number of friends $51 - 100$). When we examined the social connections between the participants, we found that 12 of the 16 participants were connected through Facebook with at least one other participant of the study.

Procedure

Before the field test began, users were asked to: (1) Access an online application which extracted social network details from their Facebook account; (2) install the Facebook application and ask their Facebook friends to also install the application; and (3) install the SSB iPhone application.

Once the mobile application was installed, users were given some time to explore the interface, execute queries, etc. and to ask us any questions or express any concerns that they had in using the application. Users were informed that this was a "test/training" period[18] and that all queries/interactions generated during the training period would be deleted when the live field study began. The live field study ran for a one-week period, from the 31st of March 2009 until the 6th of April 2009. Participants had access to a website which included full details on each phase of the user study and a frequently asked questions page for the duration of the study.

One of the authors was based in Dublin, Ireland, for the entire duration of the study to address any issues the participants had. Users were sent regular reminders and updates regarding the user study via email[19]. Finally, participants

[18]The "test/training" period took place over a weekend.

[19]We emailed participants on 5 occasions over the 7-day test period.

were asked to complete a post-study survey to gather subjective information on their experiences with the application[20].

SMS notifications

The SSB application employed an SMS notification facility to keep users informed of the interactions of other users. Any time a user issued a new query in the mobile application, an SMS notification was sent to all his/her friends that had installed the Facebook application. Likewise, users of the mobile application were informed via SMS as soon as someone answered their query.

RESULTS

Basic usage patterns

Table 1 shows the basic usage statistics generated by our study. In total, participants generated 56 queries, 171 query lookups[21] and 66 answers, which corresponds to almost 300 messages over the 1-week period. We found that users were more active in the early days of the study when compared to the latter days. If we examine the distribution of queries and answers generated per participant, as shown in Figure 4, we see asymmetry in user behaviour, with some users generating lots of queries and other users generating more answers.

Measure	Queries	Lookups	Answers
Total #	56	171	66
Mean (per-user)	3.5	10.7	3.3
Mean (per-day)	8	24.4	9.4

Table 1. The total number and average number of queries, query lookups and answers. Note the average number of answers per user reported above is across the 20 unique participants who provided at least one answer.

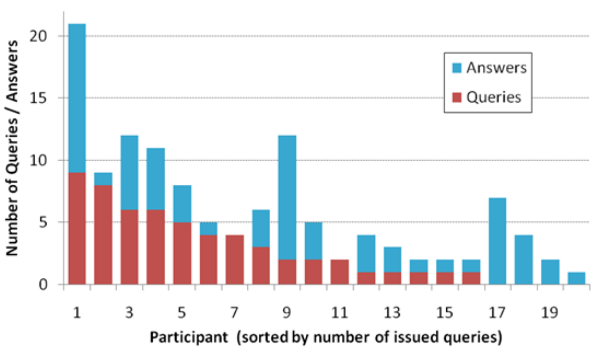

Figure 4. Number of queries and answers per participant over the 7 day study period.

Interestingly, we find that the two *standard* search results, *i.e.* Google local search and Eventful search results, provided results to the users' queries *less frequently* than anticipated by the authors: only 79% of queries returned one or more local search result (in average 4) and only 7% of the queries returned one or more event search result. Additionally, users *seldom interacted* with the search results, in particular the event search results: only six (38%) participants interacted with at least one local search result, while only one participant interacted with an event search result. Furthermore, only a single user made use of the external *"more info"* link of the search results[22].

Conversely, participants were significantly more active when providing answers to posted queries. At least one answer was submitted for 73% of the queries, generating a total of 66 answers with an average of 9.4 per day and 3.3 per user, see Table 1. Interestingly, half of the answers were generated from the SSB mobile application and the other half were generated from the Facebook application. These answers were generated by 18 unique users: 14 were participants of the SSB mobile application, while the other 4 users corresponded to Facebook friends who had installed the Facebook application. Participants engaged frequently with the *answers* facility in the mobile application: 10 (62%) of the participants interacted with at least one answer.

Types of Interactions & motivations to use the SSB

In order to gain an insight into the types of interactions our participants were involved in, we manually classified all queries and answers according to their type. In total, we identified five types of queries within the dataset and five types of answers. Their frequency of occurrence is illustrated in Table 2.

1. Location Specific Queries: We found that 57% of the queries are location specific; they refer to a specific geographical location and geographical information is needed in order to satisfy the user's information need. The vast majority of these queries include the interrogative keyword '*where*', such as *"Where is nice to go for breakfast?"* and *"Where can I buy an incase slider cover for the iPhone 3G?"*.

2. General Queries: General queries are queries which are not explicitly dependent on location. Examples include *"anything good in the cinema?"* and *"what time is it?"*. We found that 36% of queries correspond to this type.

3. Status Update Queries: Interestingly, 16% of queries correspond to this type. These queries fulfill a similar purpose to twitter tweets or Facebook/Instant messenger status updates. Instead of satisfying an information need, users are informing others about what they are currently doing or how they are currently feeling. Examples include *"waiting in the car"* and *"nice chicken roll :)"*. One user reflected on his experience with SSB and wrote *"you can see conversations starting based on queries which reminds me a little of my twitter experience"*. Note that we cannot conclude whether this behavior was primed by previous exposures to other social applications. It would have been interesting to understand whether our participants creatively adapted their use of SSB in order to achieve their goals or whether they were unclear about how to use the application which lead to a more exploratory use case. We would like to explore this further as part of future work.

4. Application Related and *5. Miscellaneous Queries*: Application related queries relate to comments about the mobile

[20] In addition some of the participants took it upon themselves to setup a Facebook group to discuss the SSB prototype and user study.

[21] A query lookup corresponds to the user requesting the query details page by double-tapping on the query.

[22] This "more info" link corresponds to a search result selection or hit. Clicking on this link brings the user to an external information website

Queries		Answers	
Location Specific Query *"Where is nice to go for breakfast?"*	57%	General Answer *"Cafe lucia is good I hear"*	53%
General Query *"Is there anything good on tv this evening?"*	36%	Conversational Answer *"having fun?"*	26%
Status Update Query *"waiting in the car"*	16%	Status Update Answer *"I'm hear"*	23%
Application Related Query *"does this wrok"*	4%	Miscellaneous Answer *"hello"*	14%
Miscellaneous Query *"jacob"*	2%	Application Related Answer *"The accuracy can vary a bit too"*	9%

Table 2. Queries and answers classified by their type along with examples

application itself, *"does this work?"*, whereas miscellaneous queries could not be classified into one of the other types (*e.g.* jokes). Only 4% and 2% of the queries correspond to these types respectively.

These observations indicate that SSB served both as a tool for inter-group communication as well as a search and information discovery tool while on-the-move. Despite the application's original design, *i.e.,* helping users satisfy their mobile information needs, it appears that the social aspects provided by the application (*i.e.* the involvement of friends, the social filter, the answers facility), inspired unexpected forms of social interactions among participants. Table 3 shows two examples that emphasize this observation. For example, it appears that a few general queries evolved into short conversations between participants. These findings suggest that our participants would have enjoyed support for conversations and not only for bulletin-board type messages.

Example 1
Q: *"where will i find a 3G signal?"*
A1: *"I found one here! 3 bars too!"*
A2: *"good man I was going to say move into the city"*
Example 2
Q: *"where is the luas?"*
A1: *"at the entrance to james' hospital"*
A2: *"cheers buddy"*

Table 3. Examples of queries and answers that correspond to little conversations among participants

Following the same methodology used for the queries we categorized the provided answers into 5 categories. Table 2 shows these five types with examples.

1. General Answers: The most popular type of answers (53%) are general answers in which the user is attempting to provide a valid and relevant answer that may or may not be location-specific.

2. Conversational Answers: 26% of answers belong to this category. Conversational answers are probes for additional details or statements/comments that appear to be motivated by the desire to chat. For example, the query *"cinema"*, generated the conversational answer *"are you looking to go see something?"*. Another example is the (status update type) query *"waiting in the car"*, to which a friend answered *"having fun?"*. While these queries and answers are not satisfying an information need in a traditional sense, they seem to be relevant as starting points of conversations.

3.Status Update Answers: We also identified a status update type in 23% of the answers. Examples include *"It's wonderful here :-)"* and *"I'm here"*.

4. Application Related and *5. Miscellaneous Answers*: Application related answers (9%) again correspond to comments about the application itself, for example *"Yeah I noticed this since getting the iPhone. The accuracy can vary a bit too"*, whereas miscellaneous answers (14%) could not be classified into any of the other categories (*e.g. "hello"*).

It is worth pointing out that some of the queries and answers fall into more than one category, particularly when it comes to *status updates*. For example, in the query *"just got caught by april fools. anyone have a good idea for one?"*, we find that the first statement is a status update, while the second statement is a general query. The answer to this query was also a combination of types: *"my boyfriend proposed this morning....and then said April Fools! he's lucky I saw the funny side"*. In this answer, the users is informing the other participant of what happened (status update), but the statement is also an attempt to provide an answer to the query.

Qualitative Feedback and Experiences

Our participants filled out a post-task questionnaire designed to elicit their experiences with SSB. The questionnaire included several open questions where participants could freely express their experience with the SSB prototype.

Some participants reported speed and responsiveness of the application to be a concern, in particular relating to the maps component. However, despite these issues, there were many aspects of the application that users enjoyed.

One user described his experience with SSB as a means of bridging connections with others: *"I liked the ability to see where friends were, what they were doing. It gave me the opportunity to feel as if I was involved even though I wasn't there, or indeed to join them if they were doing something I enjoyed."*. Another user likened SSB to an extension of his social network: *"I found the SSB App to be an extension of my normal social network. It was great to approach trading information between people and the time scale between the query and answer seemed to be much shorter than in any other social network because I had sms and email updates. The physical location was a great addition because you could appreciate the context of location in a users query. In turn giving a more helpful answer."*

Question	Mean	Median	Mode	Frequency				
				1	2	3	4	5
Q1	3.8	4	4	1	0	1	13	1
Q2	3.8	4	4	1	0	4	7	4
Q3	3.8	4	4	1	0	4	8	3
Q4	3.4	4	4	1	1	5	9	0
Q5	2.9	3	3	1	4	6	5	0

Table 4. Questionnaire results highlighting users' reactions to the proactive display.

Some users explicitly expressed that they saw the potential in an SSB-like approach to search: *"I can really see the usefulness of this app once more people are using it"*, *"I think it is an excellent idea and use of the technology at hand"* and *"The more people that use it, the more interaction and information you would get."*.

One of the goals of our open field study was to explore what types of experiences a proactive mobile interface like SSB is generating. Results to these questions are shown in table 4. When asked about viewing other people's queries and interactions, participants rated this experience as interesting ($Q1 = 4$) on a 5-point Likert scale (1=strongly disagree, 5=strongly agree and 3=neutral)[23]. Subjects also indicated that it enabled them to discover new interesting content ($Q2 = 4$), it encouraged them to think of their own new queries ($Q3 = 4$) and it allowed them to learn about the area in question ($Q4 = 4$). However, participants were somewhat neutral when asked if it allowed them to learn about people in a given location ($Q5 = 3$).

We explicitly asked participants if they liked viewing other people's queries and interactions and found that 13 users ($> 80\%$) indicated *yes*. In accordance, we found *curiosity* to be the main reason why SSB was seen as appealing. Participants liked to know what other people were doing and where they were. One participant commented *"I could tell what people were getting up to and where exactly they had been or were going. A bit like a story of their day..."*.

The reactions to the filters were mixed. It appears that some users were confused and others could see their potential but felt the filters would only be truly useful if there were more queries. However, some participants indicated that the filters provided them with complete control over the set of queries displayed on the map. Although the usefulness of the filters was difficult to test, given the low number of queries displayed on the map, we found that the *time* filter was interacted with most frequently (60% of cases), highlighting the importance of temporal information on the mobile platform.

The most highly rated feature of SSB was the answers facility. Table 5 shows details on user responses to a series of post-task survey questions. Users found the ability to add answers to queries useful ($Q1 = 4$), they liked being able to answer queries ($Q2 = 4$) and enjoyed the ability to add a location to their answers ($Q3 = 4$). Users appeared to find answers with a location more useful than answers without a location ($Q4 = 4$) and participants really liked the fact that their friends could answer their queries ($Q5 = 4$). Interestingly, users were neutral in their response when asked whether the answers provided by other people helped them satisfy their information need ($Q6 = 3$). It appears that although participants liked the answers feature, not all the answers they received were useful or relevant.

[23] All ratings reported in this section are the median rating across all participants.

Question	Mean	Median	Mode	Frequency				
				1	2	3	4	5
Q1	3.8	4	4	1	1	2	9	3
Q2	3.9	4	4	1	0	3	8	4
Q3	3.9	4	4	1	0	2	9	4
Q4	3.9	4	4	1	0	4	6	5
Q5	4.1	4	4	1	0	1	8	6
Q6	3.3	3	3	1	1	9	3	2

Table 5. Questionnaire results highlighting users' reactions to the answers facility.

Additionally, sharing knowledge and helping other people was frequently mentioned as a positive aspect of the answers component. A few exemplary comments by participants: *"I found I could share my knowledge with others"*, *"if I could answer their queries I was glad to help"* and *"it was good being able to help other people with their queries"*.

When we asked participants what they liked most about SSB, 40% of participants pointed to either the answers facility or to the SMS notifications. As described above, every time a query was answered, the person that issued the query received an SMS notification. Likewise, when a participant submitted a new query, their friends were notified via SMS. Related comments on this topic: *"The fact that it notified answers to queries by SMS"* and *"Receiving texts when queries had been answered"*.

IMPLICATIONS

SSB has proven to be a useful showcase of proactive map-based mobile social search and has allowed us to evaluate new search paradigms with real mobile users. Our results have showed that mobile users enjoyed the proactive, social nature of the SSB prototype.In the following section we outline key findings and implications for the design of future mobile information access services.

Location, privacy & curiosity

The participants of our study found the map-based interface to be an intuitive way to browse queries. Some users explicitly mentioned that they liked the ability to share their location among friends. For example, one participant commented: *"Knowing locations of friends when they execute queries can be helpful but also gives you the feeling that the distance between people is reduced."*. More interestingly, participants liked the location-based aspect of SSB because it allowed them to learn about the location of others. Our participants liked that they could see exactly where other people were when they executed queries, allowing them to *track* or *watch* others. One user commented: *"you can keep tabs on people :)"*.

Conversely, the availability of location information raised a few negative reactions: 4 participants (25%) reported that revealing one's location raised privacy concerns. Furthermore, participants asked for more control over the location component of the application. In particular, they were interested in being able to conceal or obscure their own location. When asked what they liked *least* about the application, one participant commented *"using my location and everyone seeing it."*. Another participant made a more general comment in this respect: *"it can also be a little unnerving if you post a query at home knowing that others can find where you live."*. Previous work in this area has found similar privacy concerns [20].

However, it came as a surprise to the authors that revealing one's location was significantly more problematic in terms of privacy than the actual content of the queries and answers. Participants seemed very relaxed with respect to the types of queries and answers they submitted, with very little regard for the tone and language used. In fact, some users posted queries and answers that might be considered quite personal in nature. This behavior might be explained by the fact that all our participants were active Facebook users and hence were used to sharing status updates, comments, photos and other personal content with their online friends.

One outcome from our study is that future location-based systems of this nature need to consider the importance of location-privacy trade-offs. Curiosity about our peers' whereabouts and activities seems to be part of human nature. However we tend to be reluctant to reveal these details about ourselves. One approach to address these concerns could be to allow the user to selectively decide whom a query or a location will be visible to. Alternatively, a facility for users to *offset* or *obfuscate* their current physical location could be provided. Note that 57% of the queries in our study were location specific, whereas the rest of queries did not require others to know the user's location in order to be answered. Finally, as mobile location-based services become more pervasive, we expect the users' sensitivities about sharing location information to change.

Unique characteristics of mobile information needs

Previous research has shown that mobile information needs differ significantly from standard web needs [8, 27]. The results of our user study confirm this and in fact, help us increase our understanding of what it is that makes mobile information needs so unique.

The SSB prototype leverages a user's social network to enable friends to answer queries and provide recommendations to other users. Ten users preferred this human-generated content over both the local and event search listings. Although local search engines such as Google local are very good at answering specific queries like *"starbucks"*, they are less equipped to satisfy information needs that are personal in nature or that require access to very *fresh* content. For example, queries like *"Is there anything good on tv this evening?"* and *"is anyone else on this ssb on boards?"*[24] could not be answered by a standard search engine.

Hence, it is important for future mobile information access services to consider alternative approaches to helping mobile users satisfy their needs. Such approaches should look beyond traditional search engine indices and incorporate a social/human component for access to the most relevant, personal and up-to-date content.

[24] *boards* is a well known online forum within Ireland and as such the participant wanted to know if anyone else using the SSB application was also a users of boards.ie.

Existing technologies & real-time notifications

The SMS notifications were used within SSB to inform friends of new query submissions and new answers. The authors thought of the SMS notification as a rather unimportant add-on and were surprised by the overwhelmingly positive reaction from the SSB users. Possible explanations for this reaction are: (1) Mobile phone users know from their own experience that text messages (almost) always reach the recipient. This reliability gives users reassurance that their SSB queries and answers reach their friends; (2) SMS messages are semi-instantaneous. This speeds up response time and transforms SSB from a information-pull search application to an information-push application with high interaction speeds. When waiting for an answer from a friend (or non-friend) after issuing a query, the SMS notification allows the user to shut down the SSB application and focus on something else while waiting for an answer as opposed to requiring the user to wait with no responses or updates from SSB. Finally, (3) text messages are perceived as direct human-to-human communication as opposed to other types of computer mediated human-to-human interaction such as playing in gaming networks or interacting in second life. Thus, the SMS notification shifts the perception of SSB from a search engine service towards a tool to communicate with real people.

These findings imply that utilizing trusted and reliable technologies is welcomed by users. Therefore, when designing future mobile services researchers should consider the integration of existing approaches that work well and are understood by their users. Furthermore, it appears that push-based information services are key within the mobile space, providing users with easier access to relevant and interesting content.

CONCLUSION

Mobile information access is challenging, particularly from a search perspective. Key contexts such as location, time and social interactions have significant impact on mobile information needs. In this paper, we have described a proof-of-concept research prototype called SocialSearchBrowser (SSB) which explores the social context of mobile search. SSB incorporates social networking capabilities with key mobile contexts to improve the search and information discovery experience of mobile subscribers, providing users with proactive access to interesting content. In this paper, we have presented key results from an exploratory field study of SSB and outlined a number of implications for the design of next generation mobile information access services.

We are currently investigating a few areas of future work related to the SSB prototype. We are in the process of implementing an improved version of SSB which incorporates some of the lessons we have learned. We plan to carry out a longitudinal live mobile field study involving more participants and more groups of friends. We have also identified interesting research directions that explore the social context of mobile search in more detail. For example, we found that a significant percentage of the queries and answers lead to conversations among participants. We would like to explore these social interactions in more detail and devise new approaches to utilizing these human-interactions to improve the information access experiences of mobile users.

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