Investigating Collaborative Mobile Search Behaviors

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ABSTRACT

People use mobile devices to search, locate and discover local information around them. Mobile local search is frequently a social activity. This paper presents the results of a survey and an exploratory user study of collaborative mobile local search. The survey results show that people frequently search with others and that these searches often involve the use of more than one mobile device. We prototyped a collaborative mobile search app, which we used as a tool to investigate users' collaborative mobile search behavior. Our study results provide insights into how users collaborate while performing search. We also provide design considerations to inform future mobile local search technologies.

Author Keywords

Mobile search; collaborative search; local search;

ACM Classification Keywords

H.5.m. Information Interfaces and Presentation: Misc.

General Terms

Human Factors; Design;

INTRODUCTION

Users often conduct mobile search to find nearby places to visit and to obtain more information about those places, e.g., addresses and navigational directions [11]. Recent studies of people's search behavior show that conducting mobile search is a social activity, and that frequently more than one person is involved during the search or influenced by the search outcome [2, 3, 11]. In this paper, we study the social dynamics around collaborative mobile search.

We first conducted a survey to learn about how users collaborate while performing mobile local search ($N = 63$). We found that a majority of the time, users cooperate in small groups of two or three in a co-located setting. A large number of these searches involve looking for nearby places, e.g., restaurants, attractions, and stores. However, currently there is not much support for collaborative mobile search, especially with respect to sharing search results and process. While prior research has explored how people perform mobile search in general, we focus on how people cooperate when conducting mobile search.

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We also present the results of our exploratory user study with 21 pairs of participants using a mobile search app that we developed to support collaborative searches. We asked each pair to search for restaurants and choose one where they would both like to eat lunch. While we focused on a restaurant search activity, we believe that this activity shares similar inherent properties with other place searching tasks.

RELATED WORK

Recent work has explored users' mobile search behavior through search log analysis and surveys. Search log analysis has provided key insights into search behavior, with mobile search being inherently different than its desktop counterpart. Mobile searches are usually associated with shorter and highly context-dependent queries [4]. Nevertheless, analyzing search logs is not sufficient to learn more about the context of search. Church *et al.*, Teevan *et al.*, and Morris have conducted surveys on people's search behavior [2, 3, 7, 11]. Our survey supplements their findings by looking at how users collaborate while performing mobile local search.

There exists a gap with respect to addressing users' collaborative mobile search needs. Although some prior works explore user collaboration in mobile web search, they do not take into account users' mobile needs or location context [5, 6]. PlayByPlay is a general purpose web collaboration tool which allows mobile users to collaborate with a remote user using a PC [12]. We focus more on co-located collaboration among mobile users and place less emphasis on sharing the search process than PlayByPlay. Past research has presented novel ways to enhance collaborative search in non-mobile settings. CoSearch enables distributed control and division-of-labor for co-located searches [1]. SearchTogether enables direct collaboration among small groups of people who know each other, enabling them to collaborate on both the process and products of search [8]. Other work has focused on collaborative interfaces and content presentation. WeSearch explores co-located web search on tabletops, where queries can be reused to reduce keyboard text entry, and clips of webpages are placed in containers for everyone to view [9]. CoSense supports sensemaking for collaborative web search through interactive views of a group's search activities [10].

COLLABORATIVE MOBILE SEARCH BEHAVIOR

We conducted a web-based survey, in which we asked participants about their most recent collaborative mobile local search. The survey included a mix of closed and open-ended questions. Participants were recruited through internal mailing lists at Nokia, through Facebook ads, and at Carnegie Mellon University. We recruited participants with prior mobile search experience.

Cooperation Approach	Respondents
Conducted search while receiving feedback	41 (65.1%)
Watched over someone's shoulder and suggested queries	18 (28.6%)
Contacted other people to coordinate real-time search	8 (12.7%)
Divided up search responsibilities	11 (17.5%)
Raced to see who can find the result fastest	13 (20.6%)
Other	2 (3.2%)

Table 1. The participants usually conducted search while receiving feedback from others collaborating. This was followed by watching over someone's shoulder and suggesting queries.

Survey Results

Out of the participants who marked that they had collaborated on their most recent mobile local search, 63 completed the survey. They consisted of 35 males, 26 females and 2 participants who did not report gender. They used mobile search regularly, performing search daily (19%) or weekly (52%). 68.2% of this population fell uniformly between ages 18 and 35, inclusive. Our participants were frequently searching to go somewhere (69.8%), to choose a place from a group of places (34.9%), and to get directions (38.1%). Participants were mostly looking for restaurants (60.3%), followed by other (e.g., movie theaters, bars; 14.3%), attractions (11.1%), and stores (7.9%). Participants wanted their search results to be close to their location, with 86% wanting their search results to be within 15 minutes of their location at the time of the search. Familiarity with the area of search was disbursed between somewhat familiar to very familiar. Compared to Teevan *et al.*'s results, we found that when collaborating on searches, it is more likely that the searchers are not *very* familiar with the area of search [11]. This is similar to Church *et al.*'s findings [2]. We attribute this to collaborative searches occurring when users are out exploring.

The social dynamics of the participants' searches were of particular interest to us. Users most often collaborated with friends and immediate family members followed by colleagues. Our participants reported collaborating with one other person most often (57.1%), with majority of collaborations being performed with up to 4 people (95.2%). Participants reported being co-located with their search partner(s) most of the time (77.8%) and rarely collaborating only remotely (11.1%). Approximately half of the time (49.2%), one mobile device was used for searching, followed by 2 (39.7%), 3 (6.3)%, and 4+ (4.8%) devices. The participants reported controlling the mobile device approximately half of the time (50.8%). Furthermore, we found that participants exercised a variety of search cooperation techniques (Table 1). Participants often shared the results by talking (87.3%). Otherwise, they communicated by phone (7.9%), through instant messaging (7.9%), SMS (12.7%), or other (6.8%).

MOBILE APP

We built a mobile app to study how people collaborate while conducting mobile search and also to analyze whether collaborative features are useful to searchers. We designed the app as a search solution to find points of interests, in particular, restaurants. This decision was based on our survey results,

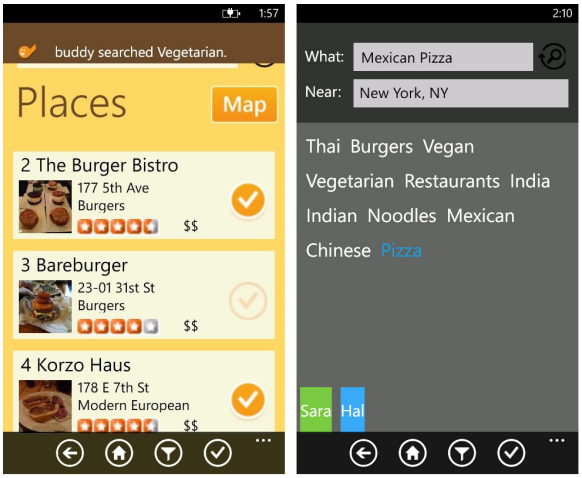

Figure 1. The collaborative mobile search app enables users to share their search process and results.

which indicated that 60.3% of the time, users are looking for restaurants. Survey participants also reported being co-located for most of their collaborative mobile search experiences and sharing the results through verbal communication. Therefore, we designed the app for co-located rather than remote collaboration. We implemented the app on Windows Phone 7 and deployed it on Samsung Focus phones. We used Yelp's (`www.yelp.com`) public APIs to present 20 results for each query and 10 full reviews for each result (Figure 1A).

The app presents users with a list of restaurants at their current location on startup (Figure 1A). Through an input textbox, it supports query based searching based on terms and location. Tapping on a result presents the user with detailed information associated with that results, e.g., the address, phone number, category, price range, number of reviews, overall rating, and individual reviews and ratings. Clicking on the address or the 'Map' button, takes the user to the map interface, which presents the locations of the search results. The app supports collaboration through three main features:

Picks List: The Picks List is similar in nature to the *thumbs up* feature in SearchTogether [8]. Each search result listed on the main page is accompanied by a checkbox (Figure 1A). Whenever the user checks the checkbox of a particular result, that result is added to the Picks List. Picked results are available to all users in a session through the Picks List. A user can remove any of the picks that were suggested by that particular user but not by the user's search partner(s).

Notifications: We included notifications in our application to improve users' awareness of their collaborators' activities. The notifications appear on top of the application page (Figure 1A) and inform users when a collaborator has searched for a particular query and its associated text. The notifications also inform the user whenever a search partner has added a pick. Tapping on a "pick(s) added" notification, takes the user to the Picks List screen. Tapping on a "partner searched [query]" notification, takes the user to the search input page and the Query Cloud screen.

Query Cloud: The Query Cloud enables users to take a look at the queries entered by any subset of the searchers involved (Figure 1B). The Query Cloud is similar to the tag cloud presented in CoSense [10]. It presents the users with an arrangement of all terms present in the previous queries of the individuals whose tabs are selected. The terms are ordered based on frequency. The Query Cloud allows users to see a big picture of what their search partners are searching.

EVALUATION

We conducted an exploratory user study to learn more about how people collaborate on mobile searches. We recruited participants from university students and also the general population. We asked each participant to bring a friend, whom we defined as someone they knew for the past 6 months and see at least 3 times a week. During the study, we asked each pair of participants to perform tasks where they would search for a restaurant that they both would like to eat lunch at and decide on one. We chose the task of finding and deciding on a restaurant, as the majority of the time, people are searching for restaurants. We had each pair conduct four tasks, which included two practice tasks to become familiar with the interface. We told our participants that they would receive a $25 gift card each to one of the restaurants that they chose during the non-practice tasks. At the end of the study, we compensated each participant with $25 in cash rather than gift card. We audio and video recorded the participants.

User Study: We conducted our user study with 21 pairs of participants (42 Total: 28 male, 14 female). 31 (73.8%) of our participants reported being 18-25 years of age and 9 (21.4%) reported being 26-35, and the rest were older. Our participants consisted of 23 students in addition to researchers, writers, attorneys, and people who were unemployed. 90.4% of our participants performed search regularly, on a daily (57.1%) or weekly basis (33.3%).

We used two versions of our mobile client for our user study to gauge how participants use and evaluate the collaborative features compared to local search without collaborative features. Specifically, we had one version which offered the application with all the collaborative features as described in the Mobile App section (the collaborative condition). The other version, our baseline, did not have any of the collaborative features (the stand-alone condition). All the participants tested both conditions. We counter-balanced the orders of the trials. Prior to the start of each condition, we showed participants a video of how the app worked. We asked each pair to search for restaurants and decide on one where both members would like to have lunch. Participants had 10 minutes to perform the task, with a reminder after 8 minutes. Between tasks, we asked participants to fill out a web-based report about the previous task. Each pair repeated this search task twice for each condition. The first task in each condition was a practice task for the pair to get familiar with the app. Thus, participants repeated the task four times in total. For each task, we specified a different neighborhood (with 20+ restaurants) where participants were asked to find a restaurant.

We performed the user study in Pittsburgh, PA. We gave participants a map of the city prior to searching and asked them to indicate 3 to 5 neighborhoods with which they were most familiar. We then made sure that we did not use these neighborhoods for our study, so that users had to actually search for places where they would like to eat. Nevertheless, we discovered that often times users were still at least somewhat familiar with the neighborhoods that we picked. This matched the condition from our survey results in that people are often at least somewhat familiar with their area of search.

Results: During the study, the 21 pairs of participants chose a total of 42 restaurants for non-practice tasks. On average each participant performed 4.45 searches ($\sigma = 3.33$) for each task (median of 4). There was no statistically significant difference in the number of searches between the collaborative and the stand-alone conditions ($t(41) = -0.44, p = 0.66$).

Picks List: The Picks List was the most frequently used collaborative feature. Each participant navigated to the Picks List 4.88 times on average ($\sigma = 4.15$), with a median of 4 times. On average, each participant added 3.10 picks ($\sigma = 2.32$), with a median of 3. We also found that participants rarely removed picks. They removed 0.45 picks on average ($\sigma = 1.11$), with a median of 0. We attribute this to there being a manageable number of picks per session. However, we had several participants who asked their search partner to refrain from adding more items to a list that already had many items on it. We also had participants who would ask their partner to add an entity to the Picks List to be viewed later. The Picks List was not only useful to share results, but also to avoid interruptions during one's own search activity.

Notifications: The notifications were used to raise participants' awareness about what their search partner was searching and when their search partner added items to the Picks List. Even though participants rarely tapped on the notifications to go to the corresponding pages (15 times total for all study sessions, used by 9 participants), in the follow-up interview, participants reported that they were aware of the notifications. Notifications allowed participants to see what their partner was searching instantly. This led to participants getting ideas for search queries from their partner. We also observed unexpected use of the collaborative features. For instance, P39 used the notification frequency as an an indicator of her search partner's rapid search speed. As such, user awareness is not only raised by the content of notification messages but also by the frequency of notifications.

Query Cloud: We generally observed that the Query Cloud was not used very often. This was also apparent in our logs in that only 10 participants took advantage of looking at another person's queries and that this feature was used only 19 times through all the sessions in the collaborative condition. With a small number of people searching, the notification feature provided similar information. In the follow-up interview, several participants pointed out that this feature would be more useful if it offered prior search history or queries that other searchers from the wider population had entered.

Most results from our study and log analysis showed that users' interactions with the two versions, stand-alone and collaborative, were usually similar. This is reasonable as both

versions were similar apart from the collaborative features. In the sections below, we highlight the differences and other interesting findings. On a 5-point Likert scale (5 strongly agree), users were satisfied with both versions (median 4, 5 most satisfied). They did not find the search frustrating (median 2), and felt like there were enough restaurant options (median 4). In the follow-up web report, when we asked participants if they preferred the application with the collaborative features, 64.3% marked strongly agree and 23.8% marked agree on a 5-point Likert scale. This may be slightly skewed by novelty effects or general preference for features.

Collaborative features promoted exploration. Users typically took longer with the collaborative version and also looked at more details. Specifically, participants' search sessions would take 5.81 minutes on average ($\sigma = 0.50$) with the stand-alone version, whereas they would take 7.42 minutes on average ($\sigma = 2.50$) with the collaborative version. In a paired t-test, the difference between the two conditions in terms of session durations was statistically significant ($t(20) = -3.0423, p = 0.0064 < 0.01$). We attribute this to participants looking at more places with the collaborative version. Pairs also looked at the result detail screen more frequently using the collaborative version (average 18.33, $\sigma = 9.74$), versus the stand-alone version (average 11.90, $\sigma = 6.48$). The difference was statistically significant ($t(20) = -3.4466, p = 0.0026 < 0.01$). We believe this is due to people sharing and exploring picks.

Participants replicated non-collaborative searches. We often found participants using the baseline version replicating their search partner's searches to compare results more easily. Participants would not only ask for their search partner's query term, but they would also replicate other search criteria such as how the results were ranked and the distance from the area of the search. Some participants would go down the list together with their partner and eliminate results or discuss results that they found interesting.

Collaborators usually exercised one of two approaches. Through observations, we noticed that users usually exercised one of two approaches when searching for restaurants. In one approach, both participants would engage in exploratory search, followed by discussing the results, looking for more places, and finally choosing one of the options. In the other approach, participants would discuss at the beginning of their search session possible categories of places that would interest them both. Their criterion would usually be the cuisine type of the restaurant they were planning to select, e.g., *Chinese* or *Italian*. We also had sessions where one participant would ask the other about places that she did not want to visit.

Participants also took into account opinion of those not present. We identified cases where participants would also take into account the opinions of others who were not present in the room, involved in the search, or even affected by the search results, e.g., common friends.

Design Implications: We present the design implications of our findings, which should provide insight into designing better collaborative mobile search solutions.

Facilitating Communication: Collaborative systems can facilitate communication. When designing the app, we granted the ability to remove a pick from the Picks List only to the collaborator who suggested the pick. This resulted in users requesting their search partner to remove picks. The request to remove a pick was usually ensued by discussion about the particular pick, which we believe helped collaborators get a better feel for search results that they would both like.

Omission List: During our study, we observed cases where participants would ask their search partner about cuisines which would not interest her. They then avoided searching for those cuisines and omitted results associated with those cuisines. Search engines can provide more relevant results by building an omission list into search apps for users to omit certain keywords or results.

Optimizing for Friends and Family: Our survey results showed that search users usually collaborate with their friends and family. Collaborative mobile search solutions can optimize for collaboration with friends or family members by offering pre-sets or sharing the preferences (e.g., dietary restrictions) of friends and family members with the users.

SUMMARY

We explored how people collaborate while conducting mobile local search, particularly searching for places, and how to better enable collaboration. Users are usually co-located when searching together, and employ a variety of cooperation approaches such as query replication. We showed that collaborative features encourage users to explore more options and allow them to decide based on a wider array of places. We also offered insights which support the design of mobile search solutions and other collaborative mobile applications.

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