Understanding the Intent Behind Mobile Information Needs

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ABSTRACT
Mobile phones are becoming increasingly popular as a means of information access while on-the-go. Mobile users are likely to be interested in locating different types of content. However, the mobile space presents a number of key challenges, many of which go beyond issues with device characteristics such as screen-size and input capabilities. In particular, changing contexts such as location, time, activity and social interactions are likely to impact on the types of information needs that arise. In order to offer personalized, effective mobile services we need to understand mobile users in more detail. Thus we carried out a four-week diary study of mobile information needs, looking in particular at the goal/intent behind mobile information needs, the topics users are interested in and the impact of mobile contexts such as location and time on user needs.

ACM Classification Keywords
H.m Information Systems: Miscellaneous

General Terms
Experimentation, Human Factors

Author Keywords
Diary Study, Mobile, Information Needs, Intent, Context

INTRODUCTION

The mobile world is growing at a phenomenal rate. In 2007, the number of mobile phone subscribers reach 3.5 billion worldwide[1] and this figure looks set to hit 4 billion in the near future[2]. Mobile Internet usage is also increasing. For example, the Mobile Data Association (MDA) show that in April 2008 over 17.4 million UK subscribers accessed the Internet via their mobile phone. This represents a significant increase when compared to the previous year figures ($<$ 16 million)[3]. Devices like the iPhone are having a profound effect on the volume of users who venture online. Figures from mobile analysts, M:Metrics, show that 85.9% of iPhone users in the US ventured online during the first three months of use[4]. Furthermore the introduction of flat rate data plans from many popular mobile operators is also driving the increased popularity of the Mobile Internet.

When it comes to finding information on the Web there is no doubt that search engines dominate as the primary mode of information access with just under 10 billion search queries submitted to leading search engines in November 2007[5]. However the same is not true on the mobile Web. Up until recently, the most popular mobile sites were accessed via the branded portals of mobile operators. However, a report by the Mobile Marketing Association (MMA) shows that the popularity of off-portal content has increased significantly in recent times. For example, in Japan, there are more than 80,000 off-portal sites on NTT DoCoMo's i-mode network while in some European markets, notably the UK and Germany, off-portal data revenues contribute up to 70% of total content revenues [17].

Mobile search has become an increasingly popular way to locate content on the Mobile Internet, especially as off-portal content continues to grow. There have been a number of studies to date that examine mobile search behaviour [1, 4, 16, 21]. Today mobile search still only accounts for a small fraction of mobile information access but there is an obvious opportunity for mobile search engines to play a much greater role in the near future. Other recent research has examined mobile information access behaviour in general [7] focusing on the differences between browsing and search behaviour, devices and search engines as well as emerging search patterns. These studies are important because they provide significant insights into how subscribers search for information online. However these post-facto log analysis studies don't capture the actual intent behind the users information need and they don't encompass all mobile information needs.

We believe that mobile search will differ significantly from

*The work presented in this paper was carried out while Karen Church was a PhD student in University College Dublin.

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[1]http://www.forbes.com/personaltech/2007/10/25/mobile-market-subscription-technology-personaltech-cz_1025mobilemap.html

[2]http://www.un.org/apps/news/story.asp?NewsID=28251

[3]http://www.text.it/mediacentre/wap_figures.cfm

[4]http://news.bbc.co.uk/2/hi/programmes/click_online/7219518.stm

[5]http://searchengineland.com/071228-150455.php

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Web search, not just because of the devices but also because people's information needs differ when mobile. Mobile users, on the move, are likely to be interested in locating different types of content, for example. In order to offer personalized, effective mobile services we need to understand mobile users in more detail. For this to happen, however, we need to better understand the characteristics of mobile information needs. Thus in this paper we describe a diary study of mobile information needs. The goal of our work is to understand the intent behind information needs and how those information needs change based on context. We compare user needs while at home, at work and while on-the-go. Our findings indicate that when users are mobile there is a clear location and temporal dependency in their information needs. When we examined user goals, we found that traditional Web taxonomies such as navigational and transactional needs were non-existent among the diary entries, thus requiring the addition of two new taxonomies that capture the unique constraints of mobility. Preliminary results from the diary study can be found in [5]. However, the work presented in this paper constitutes a more comprehensive and in-depth investigation of the diary entries generated and the implications for mobile search interfaces.

RELATED WORK

Understanding Mobile Information Needs

There are two general approaches to understanding information needs. The first approach looks at *what* users search for and *how* they search for information online, while the second approach examines *why* users search for information.

Analyzing Mobile Search Behaviour

The general Web search space has received lots of attention in this regard. For example, analysis of Web search engine query logs has provided significant insights into the types of information Web users search for, how they form their search queries and how they interact with search results [13].

More recently, studies have emerged of mobile search behaviour. For example, Kamvar & Baluja [15] conducted an analysis of 1 million page requests from the Google's XHTML search service and focused on high-level features such as the typical length of queries, target content, and the relationship between queries and device characteristics. Their findings illustrated that mobile search queries tend to be short (2.3 terms on average) and interest in niche search topics such as adult-related content is prevalent. A more recent analysis by Kamvar & Baluja is presented in [16]. Using a similar size dataset from 2007, the authors show that mobile search is changing. For example, the average query length is increasing (2.6 terms or 16.8 characters). Mobile queries are becoming less homogenous. For example, the top query in 2007 accounted for 0.8% of all queries as opposed to 1.2% in 2005 [15]. Although these findings indicate signs of evolution in the mobile search space, the authors also found an increase in the volume of adult queries — a trend normally associated with nascent technology.

A recent analysis Baeza-Yates et al.[1] is focused on a more mature mobile Internet market, i.e. Japan. The study looks at the characteristics of mobile search queries submitted to Yahoo! Japan's mobile search service. The study examines one million mobile queries and compares search behaviour to traditional desktop search behaviour based on a control set of one hundred thousand desktop search queries. The results of the study highlight a close correspondence between the number of terms in mobile queries (2.29 terms per query, on average) compared to desktop queries (2.25 terms per query). However, the study goes on to highlight a larger discrepancy when it comes to the average number of characters per query – 7.9 characters per query for mobile search compared to 9.6 for desktop search – suggesting that both the physical text input interface and language options have an important role to play. Interestingly, the authors also found significant differences in the type of content being searched for on Yahoo! Japan when compared to other mobile studies. In particular, the most popular mobile search queries related to *Online Shopping*, *Sports* and *Health* in Japan as opposed to the Adult content that appears to dominate mobile search in other markets [7, 15, 16].

Church et al. [7] analysed the search habits of approximately 50,000 mobile European searchers in 2005. The study covers the usage of more than 30 different mobile search engines, from Google and Yahoo! to more specialised mobile specific engines and operator specific search. Church et al. reported an average of approximately 2.1 terms per query but noted a slightly longer query length for queries submitted to Google Mobile. Church et al. [7] also highlighted the prevalence of Adult content among the targets of mobile searchers; 50% of the top mobile search queries related to adult content. Finally, it is worth highlighting that this previous study is unique in that it looked beyond mobile search behaviour to also include navigation-based information access to allow for a comparison between search and browsing. The study was the first to highlight the early-stage nature of mobile search with the vast majority (94%) of mobile sessions devoted to browsing only. Indeed, only 8% of mobile users were found to engage in mobile search at all, although these users tended to be involved in much richer sessions in terms of their time spent online, bytes downloaded, etc.

More recent work by Church et al.[4] focuses not only on simple search inputs (i.e. query patterns, query topics, etc.) but also on search outputs, i.e. the click-thru behaviours of subscribers. Using a large dataset comprising of 6 million searches generated by 260,000 European mobile subscribers, the authors found just 11% of queries are *successful*, that is, lead to the selection of at least one search result. The authors concluded that perhaps mobile search results are perhaps failing to attract searcher attention, in particular when compared to general Web search click-thru behaviour. Church et al. also found an increase in the percentage of adult-related searches when compared to their earlier study. 61% of the top 500 queries were classified as adult compared to 50% in their previous study.

Finally, Yi et al. [21] examined the characteristics of search queries submitted to various Yahoo's oneSearch interfaces including the XHTML/WAP interface, Yahoo! Go for mo-

bile and Yahoo! Mobile SMS. The dataset used for this analysis comprised of 40 million page views from a 2 month period in 2007. The authors were able to compare and contrast US versus international queries by extracting a random sample of 20 million page views from the US and 20 million page views from Europe and Asia. The authors found 20% more repetition among queries in the international dataset when compared to the US dataset. They also found international queries to be shorter than the American counterparts (2.1 vs. 2.35 respectively). Furthermore the US queries had less variety than the international counterparts despite comprising of more unique queries. They found entertainment searches which included adult-related queries to be the most popular topic ($>$ 40% of queries) across both datasets.

Analysing Search Intent

The second approach to understanding information needs is to examine *why* users search, i.e. the goals/intent behind their queries. This is an area within the general Web search domain that has been examined significantly. For example, early work by Broder[3] introduced a taxonomy of Web search in order to understand the actual intent behind Web search queries. In this work, Broder categorised Web queries into 3 classes according to their intent: (1) Navigational, (2) Informational and (3) Transactional. Navigational queries are queries in which the intent is to reach a particular website. For example, *google*, *hotmail*, etc. are all types of navigational queries. Informational queries are general queries in which the goal is to learn more about a topic or get an answer to a question, etc. Finally, transactional queries are those intended to *perform some web-mediated activity*. For example, queries that involve playing games, downloading music, interacting with some online service, etc. are all examples of transactional queries.

Rose & Levinson [18] extended the Broder framework by devising a hierarchy of search goals using sample queries from the AltaVista search engine. Their hierarchy involved dividing the informational class into 5 subclasses: (1) directed, (2) undirected, (3) advice, (4) locate and (5) list. They also renamed the transactional class to *resource* and again divided this class into four subclasses: (1) download, (2) entertainment, (3) interact and (4) obtain. Using three sets of approx. 500 queries randomly sampled from the AltaVista query logs, they found that almost 40% of queries were non-informational and a large proportion of the informational queries were requests to *locate* a product or service. They found a significant volume of *resource* queries (21.7-27%) while navigational queries represented the smallest goal class with between 11.7-15.3% of queries.

Jansen et al. [12] examined the intent of Web search queries using seven transaction logs from three different Web search engines containing more than five million queries. Based on this analysis, they identified characteristics of user queries based on the three classifications of user intent identified by Broder [3]: informational, navigational, and transactional. The authors implemented a classification algorithm and automatically classified a search engine transaction log from DogPile of over 1 million queries submitted by several hundred thousand users. Their findings indicated that more than 80% of Web queries were informational in nature, with about 10% navigational and just under 10% transactional. To date, this is an area that has not yet been examine within the mobile search space. However, it is likely that given the high prevalence of adult and multimedia content on the mobile Internet that the volume of transactional queries will be quite high. Although such log analysis studies provide valuable insights into what people search for, how they search for information and what the goal/intent is behind user queries, these types of analysis cannot tell us about the actual information needs of mobile users.

More recent work by Taylor et al. [20] focuses on the mobile space and looks at why mobile subscribers access information on the Mobile Internet. The authors tracked 11 early U.S. mobile Internet users over a 5 day period. The authors found the most frequent motivation for accessing information online via a mobile phone is *awareness*, a motivation usually satisfied with *status checking* behavior. The authors define awareness as *the desire to stay current,to keep oneself informed in general. e.g.: scanning email and checking news sites*. While status checking involves checking dynamic information like weather, news or sports scores during a game.

As a complement to the aforementioned studies, we believe we need to examine the types of information people need while on the move. It is likely that time and location will have a significant impact on information needs and by observing peoples behaviours in-situ we can gain some insights into what makes the mobile space unique. Diary studies provide one such mechanism for capturing data in-situ.

Diary Studies

Diary studies are a longitudinal method which allows self-recording of specific aspects of behaviour, usually using a small diary or notebook. A diary study typically asks a user to record the date and time of an event, the users location or context, information about the event of significance, and ratings about how they feel, etc. Diary studies are useful because they can help capture data in environments which would normally be difficult for an observer because of social or physical reasons, potentially leading to more personal accounts and natural behaviour[6].

The method has recently been used in a number of mobile device studies. For example, Grinter & Eldridge applied diary study methods to mobile device research looking at how teenagers communicate via text messaging as well as the purposes and nature of the conversations [10]. Colbert [8] carried out a diary study of rendezvousing as performed by university students. Rendezvousing refers to the informal, geographical co-ordination of small groups of friends,

[6]We did also consider a technique called the Experience Sampling Method (ESM) for our analysis of mobile information needs. With ESM, participants are sent messages asking them to answer a short questionnaire or provide some feedback. These messages can be sent randomly or may be triggered by some relevant event [9]. In the end we decided to pursue a diary study approach because we wanted the user to remain in control of when, where and how often they logged an information need.

family or team mates, for example meeting a work friend for lunch, organizing a group outing, etc. Participants were asked to record their actions and various usability measures while engaged in such activities.

Ito & Okabe examine the social, cultural, and historical contexts that impact mobile text messaging practices of Japanese teenagers [11]. Their first diary study was carried out in 2002 and examines *where* and *when* particular forms of mobile communication were used by a diverse set of people. Using a similar methodology to Grinter & Eldridge, Ito & Okabe asked participants to log all text messages, voice calls, email and web access, for a period of two days. A subsequent diary study examines instances of mobile phone use while on trains in the Kanto and Kansai regions of Japan.

In [14] Jones et al. carried out two diary studies which examined how peoples information sharing and communication needs were influenced by *place*. In both studies particiants were asked to keep a diary for a single day and to log their activities and information needs at 30 minute intervals. The goal of their work was to inform the design and development of location-aware community systems. The authors found that while places do impact heavily on peoples information needs, factors like activities, routines and social relationships also play important roles.

More recent research looks at the use of diary studies in mobile conditions. For example, Brandt et al. [2] present a new technique for performing diary studies under mobile conditions which involves users capturing small snippets of information while on-the-go. These snippets then serve as prompts for participants when completing full diary entries at a more convenient time.

Finally, Sohn et al.[19] carried out a diary study of mobile information needs, focusing on what mobile users attempt to find and the strategies they use to address those needs. Their study involved 20 participants and ran for a period of two weeks. They found that the most popular diary entries related to *trivia*, *directions* and *points of interest*. When they examined how users addressed their information needs, they found that 55% of entries were marked as either being address *later* or *not at all*. When asking users how they addressed their information needs at the time they arose, the most popular mechanisms were Internet based: web access (30%) and online maps (10%). Sohn et al. also found that time, location, activity and conversation were all key contextual factors in prompting information needs.

Our study is similar in nature to the Sohn et al. study. However, in our study, we look at mobile information needs in more detail, looking beyond simple topics and towards understanding the goal/intent behind information needs. Our study was carried out over a longer period (4 weeks versus 2 weeks) and in a more natural setting (that is, we sent a single weekly reminder to participants about the study instead of multiple daily reminders so as not to force the generation of information needs). We also examine the importance of context in information needs, looking in particular at the importance of location and time on the information needs that arise, and the types of answers expected by users. Furthermore by allowing users to generate entries in a variety of location contexts, i.e. at home, at work and while on the move, we can examine the correction between the location context and the types of needs that arise in such settings.

METHODOLOGY

Participants

Twenty participants took part in our study, 13 male and 7 female. The participants ranged in age between 20 and 60, with an average age of 31 (standard deviation: 10.75). Regarding professions, our selected participants comprised of a diverse mix, including undergraduate students, PhD students and post-doctoral researchers, an EVP Business Developer, a CEO of a software company, a retail manager, a telecommunications technician, a director of business development, a PR consultant and a chartered accountant. All of our participants owned a mobile phone and have experience with standard phone facilities like phone calls and SMS text messaging. Although 50% of the participants have accessed the Internet via their mobile phone at some stage, most of these users did not access the Mobile Internet frequently. Most participants reported well-known issues such as cost, speed and input/interaction difficulties as the main reasons why they did not venture online via their mobile phone.

Procedure

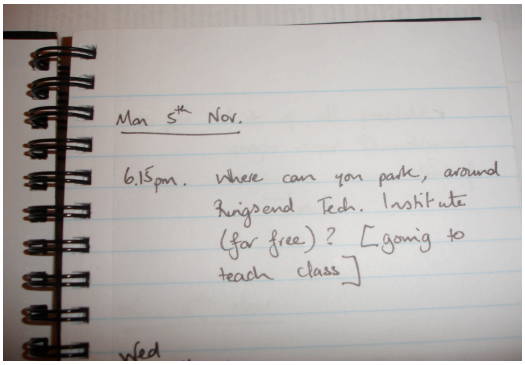
Participants were asked to keep a diary of all their information needs while they were at home, at work or mobile. We define *mobile* as being away from their own personal home or being away from their desk at work. In other words, whenever they had an information need they were asked to document it in their diary. The study ran for a period of four weeks, from the 5th November 2007 until the 3rd December 2007. Although we are primarily interested in mobile information needs we allowed users to log all information needs in order to investigate whether key differences existed between information needs arising when mobile compared to those that occur while at home or at work. Participants were asked to log the date and time, their current location, and the information need. We also encouraged participants to write down any another additional comments or notes they thought might be relevant at the time of the information need (although this was optional[7]). If participants were unable to note an information need or if they forgot to note a need at a specific time, they could do so later in the day[8].

We wanted the study to capture information needs as they occurred but in the most natural way possible. For this reason we didn't want to inundate users with daily/hourly reminders about the study. Instead we sent a weekly reminder to participants via SMS. No other incentives were provided

[7]Although comments where optional most users provided comments which attempted to explain more about the context of their information need. For example, some users gave details about what they were doing when the need arose, why they had the information need, whether they found an answer to their information need, etc.

[8]We asked participants to be as accurate as possible regarding the location and time if noting an information post-facto.

(a) Actual participant diaries



(b) Sample diary entry by participant

Figure 1. Sample diaries from participants illustrating (a) the range of notebooks used by participants as well as (b) snippets of the actual entries generated by participants.

to participants. We conducted an initial survey of participants, gathering data on their mobile phone experience and preference information. We also asked participants for clarification of any unclear entries at the end of the study.

RESULTS

Our study generated 405 diary entries, with an average of 20.3 entries per person (min=6, max=43, standard deviation=11.2). Figure 1 shows an example of the notebooks used and diary entries generated by participants. In the following sections we examine the types of information needs people expressed, focusing on the intent/goal behind the information need as well as the general topics users look for. We also discuss the impact of different contextual factors on the information needs.

Location Context

Although we allowed participants to log their information needs in a variety of location contexts, we found that the majority of the entries ($> 67\%$) where generated when the user was *mobile*. That is, away from their desk, commuting, traveling abroad or on-the-go. Figure 2 shows the breakdown of entries per location context. Probably the most striking result is that the most popular context, by a significant lead, is *on-the-go* with $> 34\%$ of entries, suggesting that many users have a variety of information needs when they are away from their familiar contexts.

User Goals

As mentioned in the related work section, previously Broder classified Web queries according to 3 classes of intent: navigational, informational and transactional [3]. We found a very different distribution of intent among our diary entries, suggesting the need for two new categories — *geographical*

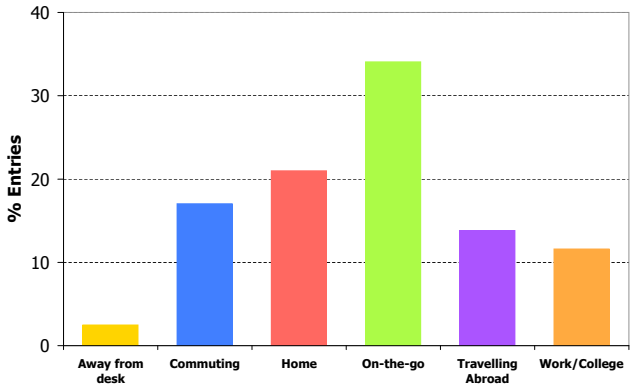


Figure 2. Distribution of location contexts highlighting under what conditions information needs arise.

and *personal information management (PIM)* — to reflect the natural bias that exists within the mobile space (See Table 1).

Informational needs are focused on the goal of obtaining information about a topic. This can include how-to's, advice, requests for general information either for something specific or something more open-ended, e.g. *"How much will a taxi to Castleknock cost?", "Is the Aresnal game on TV tonight?"*[9].

Geographical needs are focused on the goal of finding an

[9]Note that all examples provided are actual information needs generated by the participants of the diary study and as such may contain types or spelling mistakes.

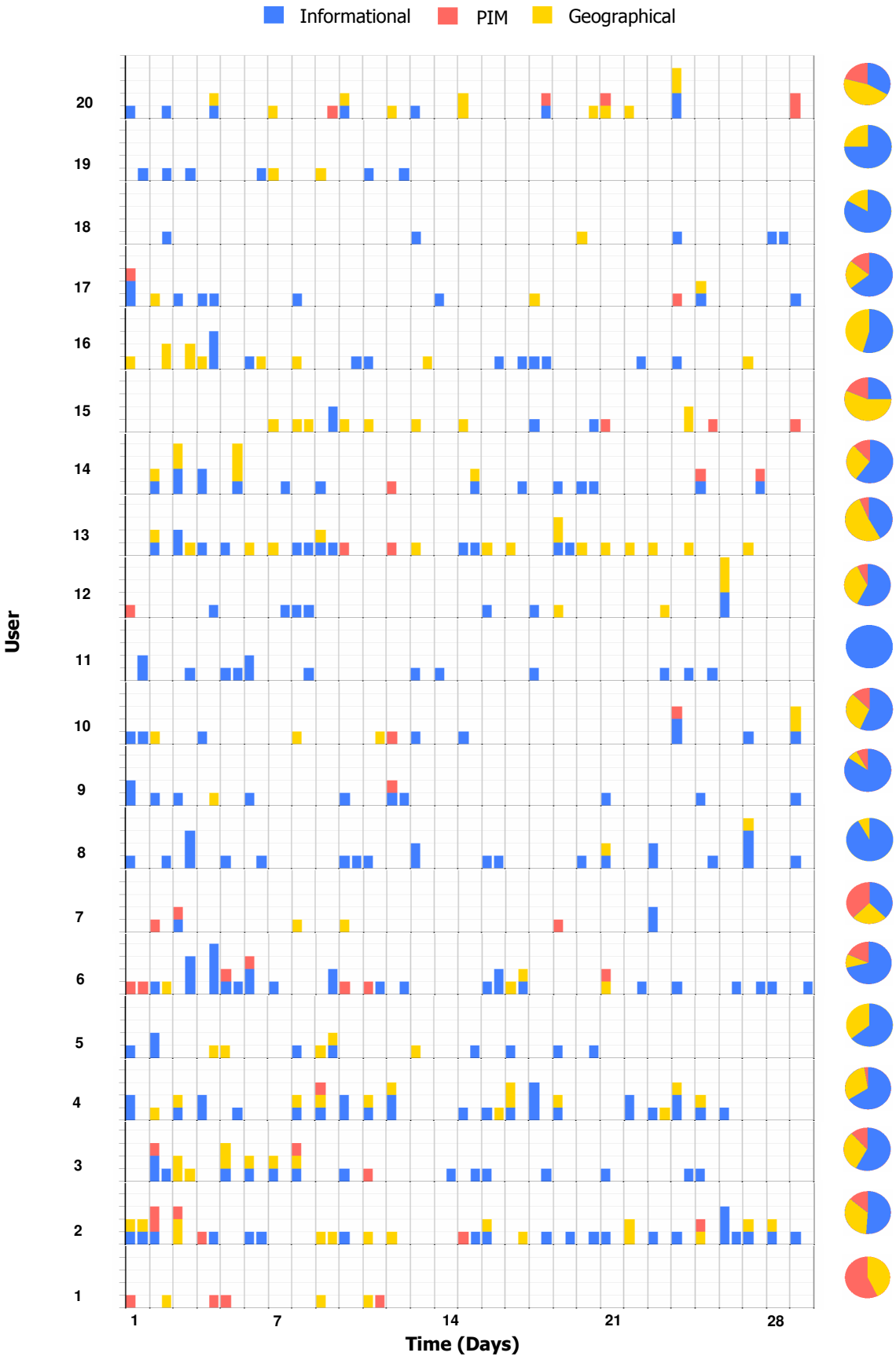


Figure 3. Individual user goals/intent: shows the number of diary entries generated per participant per day over the 4 week duration of the diary study.

Goal	% Entries
1. Informational	58.3
2. Geographical	31.1
2.1 Local Explicit	12.8
2.2 Local Implicit	14.8
2.3 Directions	3.5
3. Personal Information Management (PIM)	10.6

Table 1. Results of classifying diary entries by intent.

answer to a question, however, the information need and the answer expected is dependent on location in some form. We define 3 subclasses of this category: *local explicit*, *local implicit* and *directions*. *Local explicit* describes an information need in which the user's current location has a definite impact on the information need and the answer expected. These needs are identified by the presence of physical location/proximity keywords, e.g., *"Nearest Pennies or Dunnes Stores"*[10]*, "Where can I get Internet access here"*. *Local implicit* describes needs in which the user is searching for a *physical location* either directly or indirectly. Most of these needs are identified by the question *where*, e.g., *"Where do I get coffee?", "Looking for Vet in D12"*. Finally *directions*, describes an information need in which the user is looking for directions or an appropriate route to a physical location, e.g., *"What's the best way to get from Ranelagh to Rathfarnham?", "Direction from Belfast to Randaldstown"*.

Personal information management (PIM) information needs are focused on the goal of finding out something private relating to the individual, i.e. personal to the user in question. Normally these are questions that only the individual can answer or to answer the question, input from the individual is required. PIM needs encompass personal items, friend requests, scheduling tasks, to-do lists, e.g., *"What are my airline loyalty pin codes?", "What have I got on today?", "List of email I have to answer", "Need friends address"*.

The results (Table 1) show how almost 42% of the diary entries are non-informational and over 30% of entries are geographical in nature, suggesting a high dependency on location in mobile needs. Looking closer at the geographical category we find frequent local explicit entries (12.8% of all diary entries, 41.2% of geographical diary entries); end-users often explicitly indicate that their current location is of definite importance to the information need and the answer they would like to receive. PIM needs represent almost 11% of the diary entries. These entries correspond to information needs that are personal to the end-user. However, many of these entries cannot be answered easily by current mobile devices, for example, *"What are my airline loyalty pin codes?"*, thus highlighting the need for new PIM services on mobile handsets to help deal with these types of scenarios.

To help us understand the diversity of user goals within our dataset, we examined the patterns of high-level goals (informational, geographical and personal information management (PIM)) for each individual participant. Figure 3 shows the number of diary entries generated per participant per day. The minimum number of entries per user per day is zero, the maximum number of entries per user per day is five. Each day is divided into two segments: (1) entries generated before 6pm (shown on the left-hand side of each day) and (2) entries generated after 6pm (shown on the right-hand side of each day). The graph also presents a small pie chart for each participant, showing the overall percentage of informational, geographical and PIM entries generated over the test period. Our participants exhibited quite different behaviours, in particular relating to the intent behind their diary entries. For example, looking at user 2 we see that they requested informational and geographical needs during both parts of day 1, followed by informational and PIM needs during the first half of day 2. Overall this user's needs are split between informational (51%), geographical (35%) and PIM (14%). User 8 on the other hand has no PIM needs and only 8% geographical needs. Looking at user 15 we find that over 70% of entries occur during the first half of each of the test days and information needs are split as follows: informational (25%), geographical (56%) and PIM (19%).

Topics

Our topic analysis[11] shows that the mobile users look for very different topics than standard Web users (Table 2). Intuitively we find that the most popular mobile topics are *local services* and *travel & commuting*. Local services account for >24% of diary entries and 95% of users reporting an entry in this category. Requests for opening times of local businesses were also found in this category. Examples of information needs in this category include: *"Visiting times in Eye & Ear hospital", "Where in Dublin sells microphones for iPods?"*.

Topic	% Entries	% Users
Local Services	24.2	95
Travel & Commuting	20.2	85
General Information	15.6	85
Entertainment	12.8	75
Trivia	6.4	45
Sport	3.5	30
Email & Social Networking	3.2	40
General Shopping	3.0	25
Cooking, recipes, ingredients	2.2	35
To do/schedule	2.0	20
Stocks/finance	1.7	30
News/Weather	1.5	20
Misc	1.2	20
Personal Info	1.2	25
Education	0.5	5
Employment	0.5	5
Auto	0.5	5

Table 2. Results of classifying diary entries by topics.

Travel & commuting was also a very popular topic category with >20% of diary entries and 85% of users reporting an

[10]Pennies and Dunnes Stores are two retail stores in Ireland.

[11]We devised these set of topics by manually assessing the diary entries and combining this with information from previous mobile studies which describe popular mobile search topics[4].

entry in this category. These entries included requests for information about flights, accommodation, maps and directions while abroad as well as bus schedules, directions and traffic reports while at home. Some examples of diary entries in this topic category include: *"What's the best way to get to Westport from Dublin?", "Flight status check", "What are the train times to Tullamore from Dublin?"*, etc. Seven out of the 20 participants in our study traveled abroad at least once during our study, thus contributing to the high volume of diary entries associated with this category and we found that while abroad, the participants encountered a variety of travel-related information needs.

The *general information* topic category encompasses requests for general information. For example, *"How to tie correct knots in rope? Used for rigging equipment up mast", "Where can I find information on green cars and their availability?", "Does a Nintendo DS need batteries? If so what type of batteries?"*, etc. This category was also popular with 85% of participants reporting an entry in this category and $>$ 15% of diary entries.

The fourth most popular category was *entertainment* with almost 13% of diary entries and 75% of participants reporting an entry in this category. This topic category represents a type of *'entertain me'* category, with requests from participants for information on TV, cinema, gigs/pubs, restaurants, etc. For example, *"Places to eat. Good restaurants near Grafton St."*, *"Are there any competitions for Kings of Leon gig @ RDS?"*, *"What is on in cinema tonight?"*, etc.

The *trivia* category (6.4% of entries) encompasses fact or puzzle based information needs, synonymous with pub quizzes or random conversations with friends. Most of the diary entries in this category were seeking a single fact-based answer. For example: *"What is name of StarWars Episode IV movie?", "Who won the 1994 all Ireland hurling final?", "What year was JFK assassinated?"*

The *Sport* category (3.5% of entries) includes requests for latest fixture updates, sporting results, etc. For example, *"What was the final score in the Ireland game?"* and *"What's the early premiership game today?"*. The *Email & social networking* category (3.2% of entries) includes requests to check email as well as requests to find or contact friends. For example, *"Trying to call friend. Not answering phone"* and *"Need to check my email"*. The *general shopping* category (3% of entries) includes requests for products/shopping-related items that are not location dependent. For example, some users requested information and updates about products on eBay. The *stocks/finance* category (1.7% of entries) includes requests for exchange rates, stock prices and general finance related items. Finally the *personal info* category (1.2% of entries) are requests for information that are personal/private to the individual, e.g. *"What are my airline loyalty pin codes?"*.

Figure 4 shows the relationship between the topics and the goals/intent behind the dairy entries. We find that some topics like *auto* and *trivia* are associated with a single goal/intent, in this case *informational*. While other topics, for example

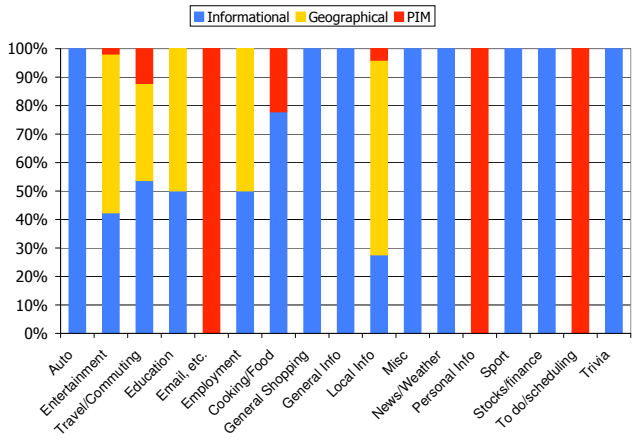


Figure 4. Relationship between topics and goals/intent.

travel & commuting, are associated with each of the three types of goals/intent.

Discussion and Implications

One important finding that emerged from our study is the importance of context and in particular the location and time of information needs, especially when the user is on-the-go. We found that over 30% of information needs were *geographical*, i.e. location dependent. Table 3 shows the percentage of diary entries associated with each goal/intent by the location context. The results show that 75% of geographical diary entries are generated when the user is mobile, compared to just 25% when the user is in a non-mobile location context. Intuitively, the majority of participants within our study sought after services and products, etc. within close vicinity to where they live, work or interact. We also found that participants who traveled away from their home town, be it for work or for a holiday, requested information to help them navigate through and learn about the new area they were visiting. We found that lots of users included explicit location/proximity cues in their information needs. For example, *nearest X*, *here*, *in this area*, *on this street*, etc. Thus location is a key factor in prompting information needs while mobile indicating that location-based services and local search could prove to be fruitful on the mobile Internet.

Goal	Mobile	Non Mobile
1. Informational	64%	36%
2. Geographical	75%	25%
3. Personal Information Management (PIM)	65%	35%

Table 3. Percentage of diary entries associated with each goal/intent (i.e. informational, geographical and PIM) by the location context, i.e. mobile and non-mobile. Non-mobile refers to entries generated while the user is at home, at work or in college while mobile refers to entries generated in all other instances, e.g. commuting, traveling, etc.

We also found a number of diary entries expressing information needs with temporal dependencies. That is, some participants requested items that included explicit temporal cues like *tonight*, *tomorrow*, *next week*, etc. For exam-

ple, *"Are the Kings of Leon playing before 17th December?"* and *"Are the Proclaimers playing vicar street or the olympia tomorrow?"*, etc. In total we found 8.4% of entries included explicit temporal cues, *"Is there anything good on tv **tonight**?"*. We also found that most of the *geographical* information needs were temporally dependent, even though most did not include explicit temporal cues. For example the entry, *"Where is nice for lunch near Jervis St.?"*. The user was walking on *Jervis Street, Dublin 1* at the time the need arose and wanted to know where in the area would be nice to have some lunch. It is likely that the user moved away from Jervis street at some point during the day, at which point the information need is obsolete. The user wanted to know the answer when the need arose. We found over 30% of diary entries were *geographical* and are likely to have some temporal dependency. Our examples illustrate that some users tend to look for fresh or new information about a topic that is only relevant at a particular point in time.

We are aware that within the mobile space there are other contextual factors that are likely to impact on the information need and the answer expected or desired by the end-user. Aside from location and time, the *activity* the user is participating in is also important. For example, we found a large number of requests for traffic updates and directions/route information. An example of such entries include *"Traffic report for Kylemore Rd"*. The individual who generated this diary entry was driving at the time and was on the Longmile Rd., which is in close vicinity to the Kylemore Rd. in Dublin, Ireland. Thus these requests originated from participants who were driving or commuting at the time and thus wanted to travel on the most appropriate route. We also found that some users provided some explicit comments to help us understand their current situation/activity and how the activity influenced their information need. For example, one user had the following diary entry: *"Whats on in Dublin tonight, any pub quizzes or promotions?"*. The comment associated with this entry is: *"bored, trying to get the lads out"*. In this case the users boredom invoked the information need. Likewise another user had the following information need: *"Where is the nearest Ulster Bank to Dublin"* and the comment associated with the entry is: *"I have to do a change order for the tills"*. Thus the user had to complete some task/action for work and as such the associated information need arose. We can see from these examples that user activity plays an important role in the types of information needs that arise.

A final example of mobile context is *social interaction/ conversation*. That is, some information needs arise by talking to friends, family, etc. For example, one of the diary entries generated by one of our participants was *"What is name of StarWars Episode IV movie?"*. The participant was in a car at the time, having a conversation with a friend. The participant added a comment to the diary entry *"So I can win argument!"*. Thus the participant was involved in a conversation with a friend and the two were arguing about the name of StarWars Episode IV movie. Another example is the following. One of our participants generated the diary entry *"Where is Hand St. Drogheda, Co.Lough?"*. The participant added the comment *"Conversation about people we knew"* to the entry. Thus the participant was again involved in a conversation with someone else when the information need was generated.

There has been some attempt by existing mobile search giants to take user context into account while addressing mobile queries. For example, Google's new mobile search[12] and Yahoo's oneSearch[13] both offer users access to location-sensitive search, ensuring that the searcher's physical location is factored into the selection and ranking of results. The current approach by Google is to allow users to manually set a default location which is used in subsequent requests to add context to searches. However, Google has recently released an automatic approach to location detection in a beta version of their mobile maps application called *My Location*. The 'My Location' feature uses information from mobile towers surrounding a user to estimate location. Although not as accurate as GPS, the My Location feature detects location within 1000m of the user on average, and it is useful for users without GPS-enabled devices[14].

Although these improvements will help users to search more effectively, they represent the tip of the ice-berg when it comes to what needs to be done. Ultimately these improvements are limited by the traditional query-based search interface on which they are based, one in which context and preferences play an ad-hoc role in guiding search. To address this issue we are currently implementing a social mobile search application called *SocialSearchBrowser*. This new application, (which builds upon our early work, see [6]), incorporates important mobile contexts such as location and time with social networking capabilities to improve the search and information discovery experience of mobile subscribers.

CONCLUSIONS

In this paper we presented the results from a diary study of mobile information needs. The 4-week diary study revealed some interesting results, in particular about the goal/intent behind mobile information needs, the topics users are interested in and the impact of mobile contexts such as location and time on user needs. We found that most of the diary entries were generated when users where away from their familiar contexts. When we looked at the intent behind the entries, we found many were non-informational in nature (approx. 42%), with geographical needs being very popular within the mobile space (>31%). The results also highlighted the importance of *personal information management* type needs (>10% of diary entries). Somewhat intuitively, our topic analysis confirmed that the two most popular topics were *local services* and *travel & commuting* (>44% of all entries).

Our diary study has also highlighted that mobile needs differ significantly from general Web needs. The key factor that attributes to this difference is that mobile users are on-the-

[12]http://www.google.com/m

[13]http://mobile.yahoo.com/mobileweb/onesearch

[14]http://www.google.com/mobile/gmm/mylocation/index.html

move and as such are interested in locating different types of content. We found context to be a very influential factor in many mobile information scenarios and as such argued for the need for new types of context-sensitive mobile interfaces that take full advantage of temporal, location, and preference-based contexts. We are currently implementing a novel interface for mobile search called *SocialSearchBrowser* which incorporates important mobile contexts such as location and time with social networking capabilities to improve the search and information discovery experience of mobile subscribers.

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