

# Patterns of Usage and Context in Interaction with Communication Support applications in Mobile Devices

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## ABSTRACT

Contact lists are one of the most frequently used applications on mobile devices. Users are reluctant to delete or remove contacts from their repositories and as modern smartphones provide an unlimited contact list storage space, these become increasingly large, sometimes measuring several hundred entries. In this paper we present our findings from two experiments with user-subjective and quantitative data concerning the use of mobile contact lists. We examine the role that frequency and recency of usage plays in the determination of a contact's importance, with a view to aid the speed and efficacy of the information seeking and retrieval process during the use of the contact list application.

## Author Keywords

Mobile PIM, Contact Lists, Context Awareness

## ACM Classification Keywords

H.5.2 [Information Interfaces and Presentation]: User Interfaces

## General Terms

Human Factors, Design, Theory

## INTRODUCTION

Undeniably, mobile devices have become part of daily life, replacing in many ways traditional personal information management (PIM) tools such as the calendar and address book. Given that the primary *raison d'être* of mobile devices, in their most popular manifestation (mobile phones), is to enable communication, clearly the importance of the contact list application and its usability in such devices is paramount. A typical communication task (making a call, or sending an email) involves finding the name and number of the desired contact as a fundamental part of completing the process. One advantage of

“electronic” contact lists is that they afford their users a very large storage space in which to store contact details, with most devices offering the ability to store several hundred or even thousand contacts in their internal memory. Given the ample space for contacts, users can quickly build large contact repositories, which include many contacts that are only needed temporarily or are very infrequently used, as well as other unrelated items such as PINs, passwords and other information scraps. Mobile devices pose notoriously difficult problems in information access and retrieval, due to the unique characteristics of that platform, such as small screens, awkward keyboards and input methods, simultaneous engagement in other tasks (e.g. walking), lack of a stable resting place as they are held in the hand and so forth. The existence of large contact repositories aggravates the problem of information access, in the sense that finding the desired contact to call or text usually requires fairly lengthy interaction and often results in frustration due to errors (e.g. calling the wrong person and starting all over again). Based on anecdotal stories and discussions with users, we were prompted to ask the question of whether the Pareto Principle (otherwise known as the 80/20 rule) actually applied to the use of contact list applications on mobile devices. If this was proven to be true, then this would have obvious implications for the design of mobile phone contact applications. In effect, it would mean that prioritization of contacts in the way a contact list is presented, according to the frequency of their use, would be highly desirable and in the spirit of well-accepted mobile design guidelines (e.g. Palm's Path to Enlightenment<sup>1</sup>). As a natural extension to this question, one has to ask whether frequency of use should be the only criterion for prioritization. In the following sections, we describe our findings from two investigations that we performed (one based on mobile users perceptions and another based on real usage data extracted from mobile phones) in examining the validity of the Pareto Principle in mobile contact list usage and furthermore our design for

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<sup>1</sup> Zen of Palm:

<http://www.accessdevnet.com/docs/zenofpalm.pdf>

(accessed 3/3/2012)

context aware criteria for the prioritization of contacts in a list.

## BACKGROUND

Although the contact list application is arguably the most frequently used function of a mobile phone, surprisingly little research has been published on evaluating its usability. In 1999, Bocker and Suwita [4] examined the usability of a C10 phone and found that although almost all users had no issues finding and calling a given contact from the phone book (94% success), this rate dropped significantly to 73% when asked to find and call the same contact from a call list. Clockar et al. also investigated the usability of several mobile phone models and found that while users typically had almost no problem calling a contact from the phonebook, there were more problems when asked to check their missed call list [6]. These findings were supported by our initial conversations with users, in which they indicated that in order to avoid searching for a contact to call or text, they would resort to looking in the call list first, particularly if it was someone they remembered having talked to recently. This is particularly true also for semi-literate users [3]. However, this might not always be the best strategy to adopt in terms of effectiveness [4, 6].

Gaur [7] recommends two interesting options for enhancing the usability of a contact list. First, marking up a contact with a Bluetooth signature of a person (to later aid the exchange of data, or notify of their vicinity) and possibly something more interesting, the use of geo-tagging to help people remember where they met a particular contact. Rhee et al. [11] recommend an altogether different approach, where a “life diary” that monitors all of a user’s activities becomes a communication gateway. The user is able to respond in any manner to any event, e.g. send an email prompted after a phone call, return a call from SMS etc. This negates the need to search for contacts in a hierarchical process to achieve a task and is much closer to our anecdotal stories that seemed to support the 80/20 rule. The authors however do not present any evaluation of their design.

Improving the contact list using context awareness was examined in a key paper by Oulasvirta et al. [10]. Perhaps the most significant finding therein was the fact that ultimately, and in line with Brown et al. [5], in situations where social factors are likely to be key to the adoption of an application, context awareness should be used to present information to the user while leaving ultimate control over the course of action to them, rather than automating it fully. Oulasvirta also makes a recommendation on the adoption of *unremarkable computing* as a design principle that makes computing transparent and supportive of the natural flow of activity, something that he attributes to Tolmie et al. [12], but possibly something that emerges from the initial theories of Weiser on the nature of ubiquitous computing. Further work by Ankolekar et al [1] discusses how a combination of contextual cues might offer usability

advantages but leaves the categorisation of contacts to users and does not present any tangible research into one of the most often used applications of mobile devices

Perhaps the most relevant item of work in this topic area is that from Jung et al. [9] who investigated the improvement of a mobile contact list using as primary design drivers the efficiency of accessing contacts and the need to differentiate important contacts. They found that users responded very positively to being able to quickly access the *top 10* contacts in terms of communication frequency, those whose *birthday* was soon approaching and additionally those contacts who were *recently added* as three special category views that helped differentiate potentially important contacts from the rest of the repository. The authors did not report any experiments in mixing the two categories in a single view and while their findings seem to align with our hypothesis for the need for differentiation, top 10 seems a rather convenient and ad-hoc number to use. Their implementation does not allow ultimate control to users, with regard to who goes into a top N list, fully automating this process for the users.

Given the small body of literature on mobile contact applications, perhaps the Personal Information Management community has findings to offer, which might be applicable to the design of mobile PIM tools. From the body of literature available, the work of Whittaker et al. [13] stands out as fundamentally important for the purposes of this paper. They asked 17 users to rate the importance of their email contacts and found that 19% of these were rated as “important” (cf. the Pareto Principle). For these contacts, the hypotheses that users would interact with them more frequently and that they would send and receive communication more frequently than from non-important contacts were verified to be true in field and lab experiments. Equally important was the finding that recent communication was very much more likely to have come from Important contacts. In the field of PIM, several authors subscribe to the school of thought that believes that as personal repositories get larger, the solution to personal information retrieval is better and more powerful search engines. It is argued that a user should not have to make a decision on whether to keep or discard information, since the search engine will ensure that information will always be found when searched for. Bergman et al. [2] wondered whether there was a middle ground in asking the question of whether to keep or discard information and considered the option of a “*Gray Area*” for folders, a visual widget at the bottom of a folder where information, which was not as important, could be placed. The researchers mention that in a recent study under review, out of 70 subjects questioned, 59 preferred one of three “demoting” designs they saw over the support offered in current operating systems.

The practice of actively promoting certain elements in a PIM data set has been observed in the past. Users find clever ways to manipulate the system in order to

differentiate between important and non-important items in a collection, such as placing the letter ‘a’ in the beginning of a file name, so it would be placed on top of a folder’s contents list and thus be quickly accessible [8]. Others use numbers to impose different levels of hierarchy (e.g. 1\_My Pictures, 2\_My Documents) on a filesystem that has no formal support for these. This practice was also recently observed in mobile contact lists. A mobile operator in the UK (O2 – Telefonica) preloads mobile devices with useful numbers such as customer services or balance enquiries in the contact lists. The entries for these preloaded numbers are preceded by a ‘>’ character (e.g. >O2 Customer Service), obviously in an attempt to keep them separate from regular contacts. This practice was also encountered with the contact list of one of our subjects, who preceded his most important contacts with the character ‘1’ (e.g. “1mummy”), to keep them at the top of his list. This was also seen in [9]. The technology behind contact list UIs in today’s devices is still based on just alphabetic lists. The Android OS provides a feature of presenting a contact list by use frequency, though again this is too simplistic a view of importance, considering just one type of context. In [14] we showed that a context-adaptive contact list can yield a significant usability advantage for users and presented one such design for a UI informed by context. For the purposes of that work, we emulated the awareness of context for the purposes of our evaluation, however, in [15] we proposed a context-oriented framework which could be used to drive a UI such as the one we discussed in [14]. We believe that one important factor in these schemes which must be retained, if they are to be formally facilitated in a UI, is the fact that users maintain ultimate control over what is promoted and what isn’t.

## **HYPOTHESIZED CRITERIA FOR CONTEXT-ORIENTED MOBILE CONTACT LISTS**

Based on the theoretical background reviewed in the previous sections and adhoc discussions with participants in our previous study [15], we hypothesized that *the criteria for contact importance cannot be static*; after all, users’ lives and priorities change continuously during the day and a truly context-aware device should continuously adapt to these changing circumstances. This gave us further insight into the question of what are the criteria for determining the importance of a mobile contact. In discussing the importance of contacts with participants, we suggest that important contextual cues that relate to mobile contacts might be the following:

**H1: Frequency and recency of use:** In [13], it is shown that frequency of use and recency of communication seem to be a fairly reliable criterion to signify the importance of email contacts. In [9] this observation seems to be supported although the authors seem to base this only on subjective evaluations (the users stated they liked that feature but no formal investigation was carried out to see if the top 10 presented contacts actually were the most

important ones for each user). Could it then be proven true that this criterion applies to mobile as well as email contacts?

**H2: Personal preference:** In the field of IR, a great amount of effort has been put into the problem of obtaining implicit relevance feedback from users. However, even designers of the best of systems admit that the ultimate form of feedback is that which comes directly and explicitly from the user themselves. Would the users feel comfortable with a fully automated system making promotion choices for them, or does some form of control (even if it doesn’t result in optimal performance) afford the contact list application greater satisfaction in its use?

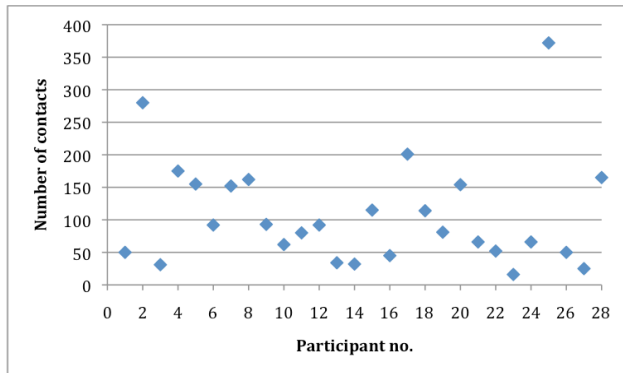
Though the rest of this paper focuses on the analysis of H1 and H2, it is natural to assume that additional contextual information might also play a role in determining contact importance. We believe that such criteria could be spatial context (where is the user currently in terms of actual coordinates or abstracted locations, e.g. “London” or “Work”), temporal context (the weekday, time of day and perceived meaning, e.g. “2pm on a Sunday”) and task or current activity context (what is the user engaged in just now, e.g. “in a meeting with John Doe” or “commuting from work”). The “implications for design” and “future work” sections of this paper discuss how interface design could be informed by these additional criteria, though investigation of these is left in the sphere of future work.

Two final questions remain to be asked in the investigation of this topic. Firstly, what is the relationship between the aforementioned hypothesized context criteria (Q1)? Is one more important over the other, or does their weight also vary depending on a fourth (or more) types of context? The second question that remains unanswered is, assuming that determining contact importance has been made possible, how does this information get relayed to the user through the contact list UI (Q2)? We are not fully convinced that the design proposals in [9] (presenting multiple group views that the user navigates through) is optimal. Under the principle of *unremarkable computing*, we hypothesize that it is not necessary for the user to know why a particular contact has been promoted, neither that they should have to explicitly change the interface’s display modes with every search for a contact. A single but intelligently adaptive user interface should suffice. The following sections discuss our findings concerning the proposed criteria H1 and H2 and present some preliminary UI mockups that could emerge.

## **USER-SUBJECTIVE ESTIMATION OF MOBILE CONTACTS USAGE**

We began our investigation by conducting a survey of the usage of contacts in mobile contact lists. Our aim was to find out the frequency of use of contacts and whether a distinct pattern would emerge that would allow us to judge the importance of contacts. We wrote a mobile application that uses the J2ME JSR-75 PIM API to export a copy of the

contact lists of 28 subjects (26 male, 2 female) aged between 18 and 31 years to a text file. We began our analysis by examining the size of the contact lists of our participants. In total, the participants' contact lists contained 3004 entries. We found that on average, each contact list contained 107 entries (mean. =107.57, stdev. =81.46, min. =16, max =372), which shows that searching and filtering contacts has to be made on a considerable corpus. This fact explains why users mentioned frequently resorting to their call lists and using special characters to "promote" contacts.



**Figure 1. Distribution of contacts amongst participants**

We formatted the contact lists into spreadsheets and sent these back to the participants over email, asking them to tell us for every contact therein, how long had it been since they last used that particular contact. To facilitate their input, the spreadsheet columns could only be populated with pre-determined answers. We additionally asked the participants to subjectively evaluate the importance of each of their contacts and indicate those who they perceived as very important (not only in terms of frequency of use, but also importance due to emotional, work or other reasons). Unfortunately, not all participants returned their annotated contact lists, and as such we received 14 (13 male, 1 female) responses to our request for data. Table 1 shows the answers the 14 subjects provided and a breakdown of the statistics for each answer.

Cumulative percentages from Table 1 show that 31% of the contacts were used in the last month and 40% in the last two. The cumulative percentage for the periods of 1-2, 2-3 and 3-6 months, shows that only 23% of contacts were used between the last 1-6 months. Finally, it is striking to see that 46% of the contacts haven't been used for at least 6 months or were never used. The design implications from these findings are obvious – it appears that just under half of the contacts objectively don't seem to be of much use to the subjects in our experiment. If we remove these seemingly unused contacts from consideration, we are left with the data as shown in Table 2.

Confirming our suspicion mentioned in the introduction, the *Pareto Principle* seems to arise again in the adjusted data, with ~19% of the contacts in our sample being used at least

once on a weekly basis, aligning with Whittaker et al.'s observation of a relationship between frequency and importance. As mentioned previously, we asked our participants to indicate how many contacts they thought of as important, regardless of frequency of use. Of the 14 respondents, 9 (8 male, 1 female) provided this information, which resulted in the interesting findings in Table 3, which seem to confirm that frequency of use is a strong indicator of importance, although we cannot ignore the fact that entries exist across all frequency categories. This leads to the conclusion that in designing a UI that allows quick access to important contacts, we should allow users to define who these might be.

|  |             |                |
|--|-------------|----------------|
| I use this contact every week                    | 131         | 10.03%         |
| I used this contact within the last month        | 280         | 21.44%         |
| I used this contact between 1-2 months ago       | 118         | 9.04%          |
| I used this contact between 2-3 months ago       | 82          | 6.28%          |
| I used this contact between 3-6 months ago       | 90          | 6.89%          |
| I haven't used this contact for 6 months or more | 341         | 26.11%         |
| I never used this contact                        | 264         | 20.21%         |
| <b>Total</b>                                     | <b>1306</b> | <b>100.00%</b> |

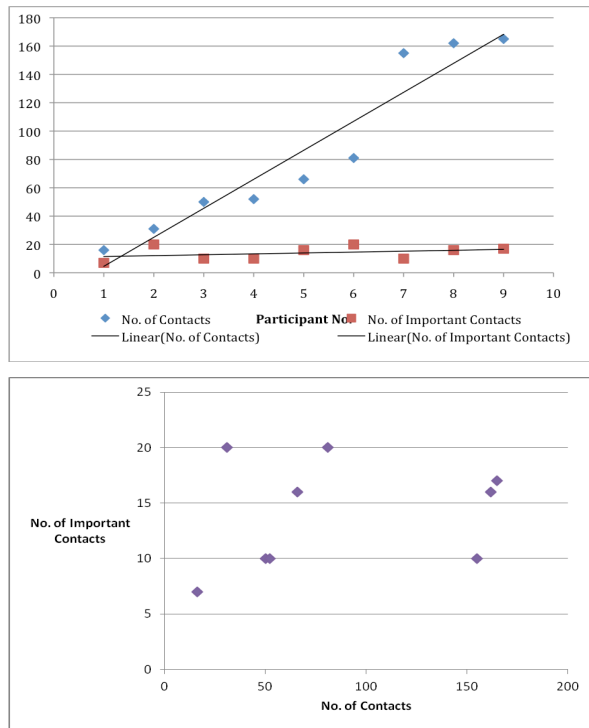
**Table 1. Contact List Usage Pattern**

|  |            |                |
|--|------------|----------------|
| I use this contact every week              | 131        | 18.69%         |
| I used this contact within the last month  | 280        | 39.94%         |
| I used this contact between 1-2 months ago | 118        | 16.83%         |
| I used this contact between 2-3 months ago | 82         | 11.70%         |
| I used this contact between 3-6 months ago | 90         | 12.84%         |
| <b>Total</b>                               | <b>701</b> | <b>100.00%</b> |

**Table 2. Adjusted Contact List Usage Pattern**

| Frequency of Use of contacts : | % of Important Contacts |
|--------------------------------|-------------------------|
| Every week                     | 42.86%                  |
| Within the last month          | 36.51%                  |
| Between 1-2 months ago         | 8.73%                   |
| Between 2-3 months ago         | 1.59%                   |
| Between 3-6 months ago         | 1.59%                   |
| Not used for 6 months or more  | 0.79%                   |
| Never used                     | 2.38%                   |

**Table 3. Subjective Importance & its relation to use frequency**



**Figure 2. Size of contact list v. number of important contacts**

Finally we examined the relationship between the size of a contact list and the number of important contacts contained therein. We found that the number of important contacts remained relatively steady despite the increase in size of the contact lists (Fig. 2) and that no statistically significant correlation can be found between the number of contacts and number of important contacts ( $r(9)=0.21$ ,  $p>0.58$ ). According to these findings, contact list UI should, as such, be able to provide quick access to approximately 20 important contacts.

#### MOBILE CONTACTS USAGE BASED ON REAL DATA

The second part of our research included an analysis of real data extracted from mobile phones. For this purpose we wrote an Android application that extracts the contact list (and “starred” status), the call log, the SMS log and the existing contact groups from the mobile device in a text file. The application was delivered to 42 subjects with Android smartphones, however only 34 datasets were considered as valid, since some were incomplete (e.g. extremely small number of records in call log or SMS log etc.). Concerning the 34 subjects that we take into account in our analysis, 31 of them were male and 3 female, while their age ranges were from 19 to 39 years old and they were from varied backgrounds, though most were Computer Science students. In this section we present findings from the statistical analysis of the overall dataset. Once again, we began our analysis by examining the size of the contact lists of our participants. In total, the participants’ contact lists contained 5384 entries. We found that on average, each contact list contained 158 entries (mean. =158.35, stdev.

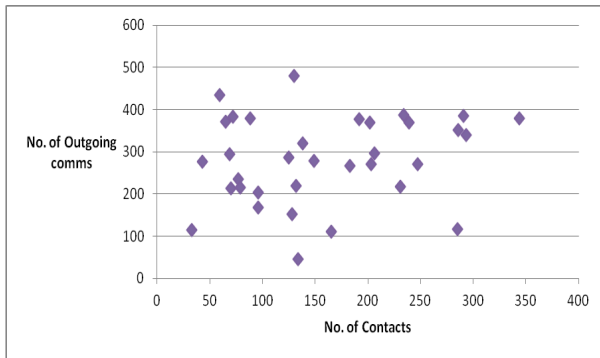
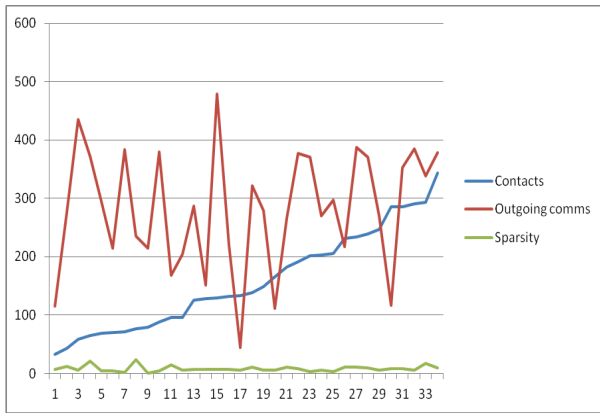
=84.74, min. =33, max =344), results that are quite similar to those from our first experiment. An interesting point is that 15 of the participants had used a feature of the Android OS that allows users to indicate their personal preferences (marking a contact as starred) and promotes the preferred contacts at the top of the contact list’s favorite tab.

The extracted logs covered a different time period in days for each mobile phone (mean=.48.88, stdev=41.66, min.=8, max=187). We calculated the sparsity of communication for each mobile user, by dividing the number of outgoing communications (calls and SMS) by the number of days that the call log covered, as an indicator of the daily phone usage. In Figure 3, the relationship between sparsity, outgoing communication and contact list size is shown. It is apparent that the way people use their mobile phones to communicate does not depend on the size of their contact lists. This is in line with our previous subjective findings, if one is to accept a relationship between the frequency of use and the importance of a particular contact.

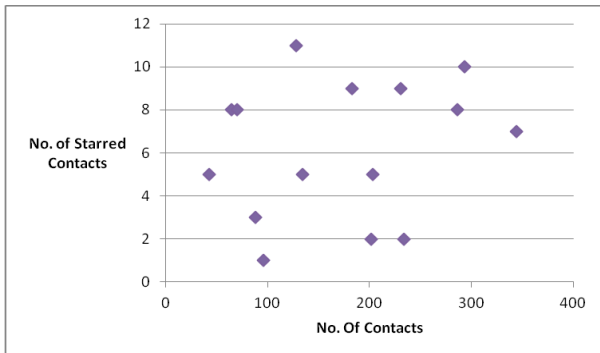
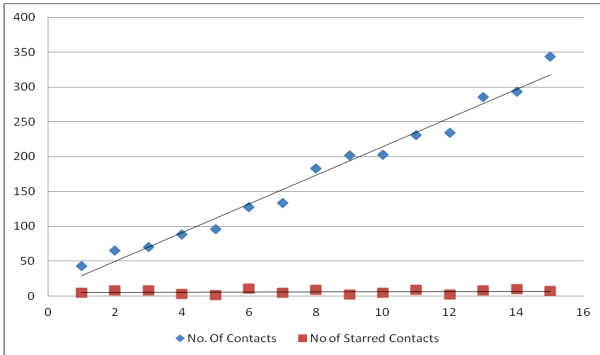
Moreover, we examined the relationship between the size of a contact list and the number of starred contacts contained therein, obviously excluding any users who did not use the “starred” contact feature. Once again, we observed that the number of important contacts (since a starred contact can be perceived as declared important) remained relatively steady despite the increase in size of the contact lists (Fig. 4). We found no statistically significant correlation between the number of contacts and outgoing calls ( $r(34) = 0.15$ ,  $p>0.4$ ) or sparsity ( $r(34) = 0.03$ ,  $p>0.85$ ).

We also examined the correlation between number of starred contacts and number of total contacts, where again we could not ascertain statistical significance ( $r(15)=0.21$ ,  $p>0.46$ ). In this case, however, the average number of starred contacts (mean=6.2, stdev.=3.16) is lower than the number of important contacts in our subjective study. We assume that this difference is the result of a combination of reasons: a) people tend to overestimate the importance of some contacts and this is also the reason why they are reluctant to delete contacts from their contact list and b) people tend to set up their starred contacts once and they do not usually change this setting.

As a result, the number of contacts that a contact list should provide quick access to, seems to be smaller than assumed earlier from the subjective user reports. (approximately 10 important contacts).

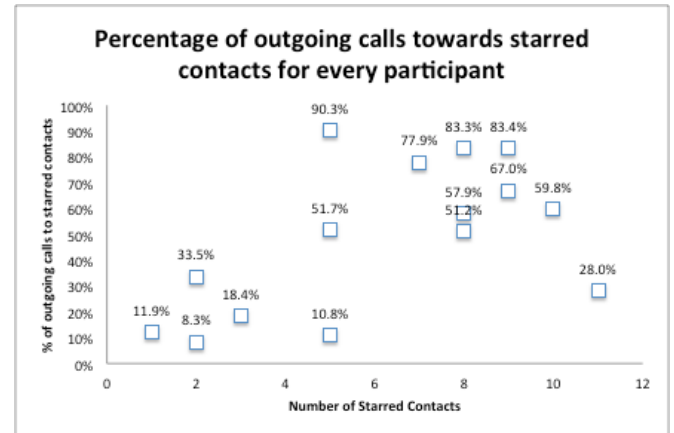


**Figure 3 a (top) and b. Relationship between contact list size, outgoing communication and sparsity for each subject**



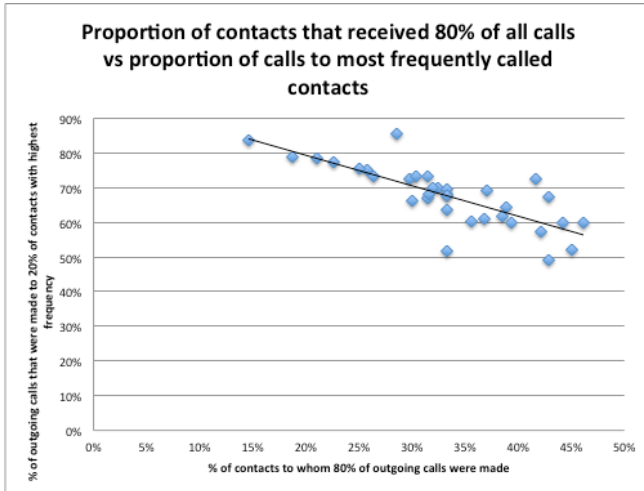
**Figure 4 a(top) and b. Size of contact list vs. number of starred contacts**

We also examined the percentage of outgoing calls towards starred contacts (figure 5). Some participants had the same number of starred contacts (e.g. 2, 5, 8, 9). An interesting finding is that for most users the percentage of outgoing calls towards starred contacts is significantly high. Specifically, for 60% of mobile users that use the “starred” feature of Android more than 50% of their outgoing calls were to starred contacts, a fact that reinforces our opinion about the importance of personal preference as a contextual cue related to mobile contacts. On the other hand, there are a number of participants who do not seem to communicate very much with their starred contacts. The same explanation as earlier about setting this feature only once could also apply in this case (most of these participants have the fewest starred contacts). Moreover, the fact that a participant considers a contact as being important in real life does not necessarily mean that she communicates this contact often using the mobile phone. For example, while a participant had his father as a starred contact, he claimed that he does not use his mobile phone to communicate with him since they live at the same place.



**Figure 5. Number of starred contacts and percentage of outgoing calls towards starred contacts for each participant**

Next, we examined if some form of the *Pareto Principle* is also valid for real usage data. For this reason, we calculated for each participant the percentage of contacts to whom 80% of outgoing calls were made and the percentage of outgoing calls that were made to the 20% of contacts with the highest call frequency. We should note here that we did not take into account contacts from the contact list that the participants had not called during the period that the call log covers. Only 15,92% (857) of the contacts in the contact lists of all participants were present in the call logs, while the rest 84,08% were not used at all. The results for each participant are presented in Figure 6. The first observable outcome is that the proportion of calls made to the 20% most frequently called contacts declines, as the proportion of contacts that makes up for 80% of the calls rises. This is expectable behavior and we observe that there is a clear negative correlation in this case ( $r(34)=-0.78$ ,  $p<0.01$ )



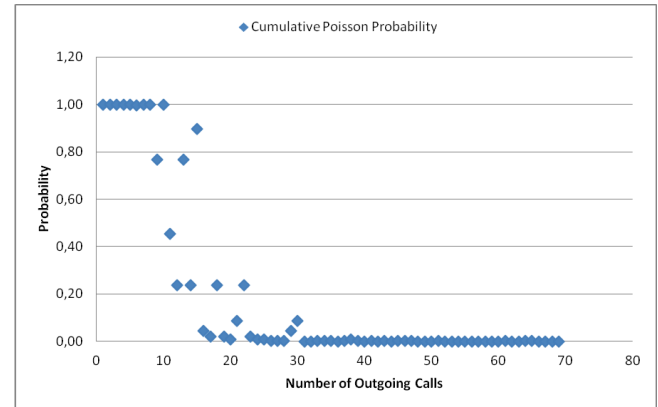
**Figure 6. Percentage of contacts to whom 80% of outgoing calls were made and % of outgoing calls that were made to the 20% of contacts with highest call frequency for each participant**

While the *Pareto Principle* does not seem to arise in the exact form of the 80/20 rule, for most participants there seems to be a relatively stable relation: 80% of outgoing calls are usually made to 25%-35% of contacts and usually 65%-75% of outgoing calls are made to the 20% of contacts with the highest frequency. This finding is in line with our belief that the proposed H1 criterion plays a highly important role as a contextual cue for mobile contacts. In addition, it seems that a relatively small percentage of contacts are frequently used (remember that in our analysis we excluded contacts that were not used at all), while the user has to search in a large repository (contact list) to retrieve the required record and for this reason mobile contact lists UIs should take this into account.

Finally, we proceeded to examine the relationship between calling frequencies and the number of contacts that correspond to each frequency value (i.e., the number of contacts called once for all mobile users, the number of contacts called twice and so on). In order to achieve that, as the call logs cover different time periods we performed a normalization on the data by extrapolating the usage behavior for a set period equal to the average + 1 stdev for all users (i.e. 49 days, mean=48 days, stdev=41). Then, we sorted the pairs of outgoing calls and number of contacts by the number of outgoing calls and calculated the cumulative Poisson probability for each pair. As shown in figure 7, the data can be split in three discrete areas of high, low and unpredictable (chaotic) probability behavior. From this data, we can see that all contacts in our dataset have a probability of having up to 8 calls associated with them of almost 1. The behavior then varies unpredictably until it settles in the region of 31 calls. This means that for our population dataset, if a contact has received more than 31 calls, it then belongs to a very special group of rare contacts. In fact, this group represents just 7.3% of the contact population with at least one call in the extrapolated

period (832 contacts). The chaotic area represents approximately 21.5% while the high probability area represents 71.2%. We cannot of course claim that the group of rare contacts is persistently important because they have received a large number of calls, however they must have, at some point in the users' log of daily life, been important due to the large volume of calls made to them.

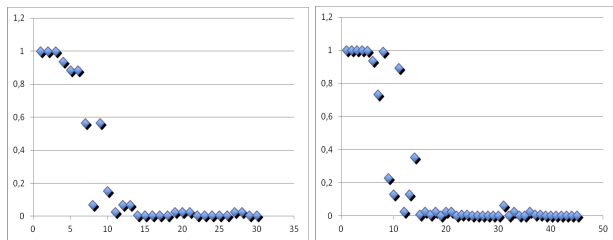
A very similar behavior in the distribution of the cumulative probabilities arises even if the data is not normalized as in our previous example. We wanted to see whether this pattern of behavior was repeatable for various timeframes of call log coverage and thus split our dataset in five distinct groups of log coverage periods (Table 4) and performed the same analysis for each group. We were surprised to find that the same behavioural pattern in the distribution of probabilities arises for each group, irrespectively of the size of the coverage period (Figure 8). Particularly surprising was the fact that the size of the low probability area (thus possibly contacts) in relation to the respective dataset remains the same (Figure 9) and hovers around the 11% mark (av. 10.93%, stdev=1.7%). The findings for group 5 show irregular behavior, but this is due to the fact that we only had two users that fell within this group. These results indicate a critical point where a phase shift between commonality and rarity for a contact, in terms of their usage frequency, occurs.



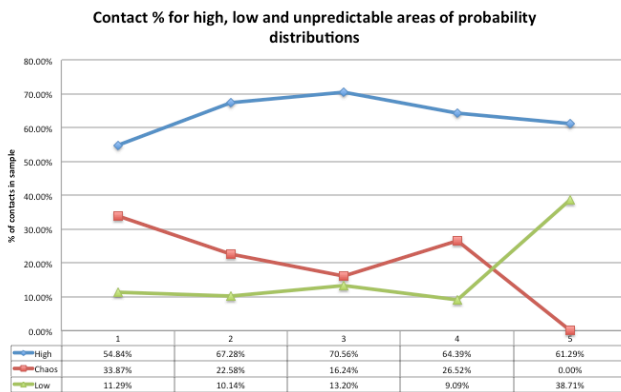
**Figure 7. Overall cumulative Poisson probability distribution**

| Group | MinDays | MaxDays | Av Days | D-Days |
|-------|---------|---------|---------|--------|
| 1     | 8       | 14      | 11      | 7      |
| 2     | 17      | 31      | 24      | 15     |
| 3     | 35      | 64      | 49.5    | 30     |
| 4     | 74      | 115     | 94.5    | 42     |
| 5     | 170     | 187     | 178.5   | 18     |

**Table 4. Groups of users and call log coverage periods (gaps in the groups are due to the sparsity of data)**



**Figure 8. Cumulative Poisson probability distributions for groups 2 (left) and 3 (right)**



**Figure 9. Relative size of the high, low and chaotic probability areas for the different groups.**

This is an important finding because it shows that we can abstract the number of contacts that are potentially important under the frequency of use criterion for any user, irrespectively of the dataset covering any given time period of interest. As such, we can find the contacts that are “globally” important to the user according to the frequency criterion for his entire data log, as well as those contacts that are “locally” important in terms of a pre-determined temporal context (e.g. this week, last month). Furthermore, based on this figure, and assuming that use frequency is the primary criterion, we can further limit the application of other criteria to just the body of the contacts that are locally contextually important. The design implications of this finding for the improvement of mobile applications to support or encourage communications by minimizing searching behaviours are discussed in the next section.

### IMPLICATIONS FOR DESIGN AND USABILITY

Understanding the importance of contacts given the user’s current context can yield significant advantages in the usability of mobile applications that make use of a contact list, whether these are for calling, texting, communication via social or VOIP networks, sharing files and also discovering content pertinent to particular contacts (e.g. messages, files, pictures etc). An adaptive interface that permits quick access to important contacts offers a distinct usability advantage [14].

We hypothesized that importance can be estimated using a variety of contextual information. An interface informed by

context can hide the source of its behavior or expose it and afford the user direct control over it. To highlight our vision, we discuss a few concept interface designs.

In figure 8 a one-dimensional hybrid interface is presented, where contacts are sorted alphabetically, but for each letter the important contacts are on top of the list and the remaining follow in alphabetical order. In contrast with our previous work [14], we can now safely limit the number of important contacts presented to the user using a threshold, as discussed in the previous section. This threshold can be adapted based on the time window used to sample frequency and recency data, so that it can represent a temporal locality (last 7 days) or global importance (complete log history). Such an interface abstracts and hides the mechanics of importance estimation from the user by revealing just the ordered and grouped contacts’ names, without offering clues or control on how this is achieved. As such the user does not know whether the grouping is due to call frequency, recency, location or time. In our example, the user is only given information on the perceived location (work) and a button to change it, in case this is wrong. In figure 4b, the context is exposed, allowing the user to understand more fully why a contact has been selected as important (e.g. Jon Marshall has been called only 15 times but tried calling 15 minutes ago, so the user might want to get back to this person. Of course their importance shall fade very quickly if the user does not react). The downside of course is the potential information overload, which may ultimately detract from the goal of offering speedy access.



**Figure 10. Hybrid one-dimensional mapping of importance (important contacts are highlighted in bold but ordered alphabetically so as to maintain user familiarity with existing UIs).**

In figure 5 we show some concept renderings of 2-d and 3-d retrieval interfaces. In the case of 2 dimensions, the

dimension of time can be preserved and as a result the user is able to retrieve the most important contacts during each time period. Figure 5a shows a more powerful interface, inspired by Apple's Time Machine software for restoring backed up data. In this example, the user is afforded control over the context information used by the device to calculate contact importance and can move time backwards and forwards, by using the time slider on the right, as well as manually change their location. This allows the user to gain future insight, as well as refer back to the past. Finally, in the case of 3 dimensions an example of how this technique extends beyond the domain of contact lists is presented. The respective figure (5b) shows how several personal information items or communication tasks (contacts, e-mails, SMSs etc.) could be projected in a 3-dimensional space (with possible dimensions presented on the axes of time, importance and distance from current location).

At this point in time our work focuses on a context-enabled contact list and following trials will extend to support a richer information space that will include all types of media and information pertinent to those contacts, enabling a new mode of context-based search and retrieval for mobile devices. As it can be seen, the determination of contact importance can naturally lead to the prediction of tasks or means of communication, facilitating use of the device and encouraging communication.



Figure 11a (left) and 9b (right). Retrieval UIs using 2D (left) and 3D (right) projections of item (contacts, e-mails, photos etc.) importance combined with retained, unprojected dimensions (time, distance from current location).

## CONCLUSIONS AND FUTURE WORK

We presented our investigation of 2 context criteria for the design of adaptive mobile contact list applications. We performed two experiments, one based on users' perceptions and another based on the analysis of data collected from Android devices. We present findings that

support the importance of proposed criterion H1 (frequency & recency of use) in the design of mobile contact list UIs. It seems that the largest part of a mobile user's outgoing communication involves a small number of contacts from her usually large contact list repository. These findings support that further research is needed in order to create new mobile UIs that will include the appropriate number of contact elements presented in an efficient manner. We also found evidence that user preference for importance (H2) should also be catered for in an adaptive UI for mobile contact lists. We strongly believe that the weights of the above mentioned criteria are not static, but dynamic, changing according to the mobile social user context. To evaluate the relationship between importance hypotheses, we are currently testing an adaptive contact list UI, informed by the design principles supported by H1 & H2. The most important contribution of this work however is evidence that user calling behavior demonstrates a repeatable pattern of use which is exploitable for the design of context-relevant contact and communication UIs regardless of the temporal scale of observed interaction.

As stated previously, frequency, recency and personal preference might not be the only contextual criteria for importance. Our research opens up questions regarding other contextual information such as *location* and *temporal context*. Our participants indicated that their calling habits depend on the location they are in. For example, when at work, they tend to use their mobile to contact work colleagues. In the evenings, when they are at home or out having fun, they would rarely do that, spending instead most of their communication time to connect with friends, relatives and some work colleagues who they are friendly with at a personal level. Could, as such, location and temporal context inform the dynamics of contact list displays?

*Social, Task and activity context* might also play an important role in determining contact importance. Knowing who a person is likely to need to communicate or collaborate with in the near future could also have an impact on elevating that contact's importance, even temporarily. Contacts who are regularly unimportant can suddenly become of critical importance for a short period of time, for example, when on our way to meet someone. Could the contact list interface with a user's calendar and try to guess their upcoming activities, who they're going to meet, and prepare itself accordingly to support the user in the likely event they need to call that person? If so, how long before or after the meeting does that contact remain important?

In the future we intend to complete the analysis of our collected data, performing a more detailed processing that will include recency dependencies, contact groups and incoming communication. Furthermore, we are preparing another experiment that will run simultaneously in our participants' mobile devices collecting data for the same

period of time and enhancing them with spatial information as well as activity information from users' calendars, enabling us to better examine hypotheses 3 and 4.

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## **Contribution statement**

We examine contact usage frequency as a context criterion for contact importance, aiming to use such information to design adaptive interfaces. We uncover scale-free behavior in global and localized context.