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Time based search call logs using ESM

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Abstract

Now a days latest mobiles are introduced duel slotted sim and when entering the caller's names in the phone, if there are same name and different numbers then it will stored in the phone after storing it will difficult to identify the number. We designed an algorithm to build a search list based on mobile phone call logs. Call logs provide the time-dependent calling patterns of mobile phone users, and therefore a search-call list based on them will be more successful in recommending a desired number than a search-call list based on recent calls . This paper presents the design process of our algorithm for an search-call list, its verification result with recorded call logs, and in-situ evaluation results of the algorithm using an Experience Sampling Method (ESM) system.

Keywords: ***Search-call list, call recommendation, calling pattern, experience sampling method.***

Introduction

Since a mobile phone is usually a single-user device, we can collect personal context information from phone usage logs. For instance, call logs reveal how often and who a user calls in different contexts. Such context information may enable a mobile phone to intelligently predict and recommend a number to call to a user in a certain context. In this research, we designed a method to generate an search-call list that can enable faster searching a recent-call list base on the time, name, number or a phonebook. We could verify the effectiveness of our method using "unseen" call logs.

Also, we implemented our method on a mobile phone, and conducted a field study, where we used an ESM system to collect in-situ user feedback and comments about the usage of the search-call list.

Related Work

A mobile phone these days can store thousands of phone numbers, and therefore provides various methods to efficiently select a number, such as group filtering, searching with a partial name or a partial number, and using a recent-call list. These methods require typing a word for searching, typing a partial number or a partial name, or repeated button clicks for selecting in a long contact list. Some researches tried to improve this process by reorganizing a phonebook considering the total calling time or the number of calls. The total calling time and the number of calls in fact are only a part of information that call logs can provide.

There were some computerized ESM tools to evaluate mobile applications, and Momento is one of them which support in situ remote monitoring with server/client architecture.

SURVEY ON CALLING PATTERNS OF CALL LOGS

We conducted an online survey with 75 participants (16-63 years old) to study mobile phone usage patterns. More than 90% of participants have been using their mobile phones more than 5 years. One of the survey results showed that searching with a name in a phonebook menu and selecting from a recent-call list comprise 72% and 64% of all responses among various calling methods. (Table 1) Another survey result about regular call destination showed that 67% of respondents have a number to call regularly. Parents (51%) and lover or spouse (44%) were ranked high, and friends (21%) and brothers or sisters (15%) followed.

How do you make a phone call?	Response Rate
"Searching with a name" in a phonebook	72%
Selecting a number from a recent-call list by pressing send button	64%
Use shortcut by long click of specific number	42%
Typing a partial name at home screen	28%
Typing a partial phone number at home screen	25%
"Searching with a categories" in a phonebook	17%
Select a number to call from SMS list	16%
Type whole phone number at home screen	9%

Table 1. Survey result about calling methods

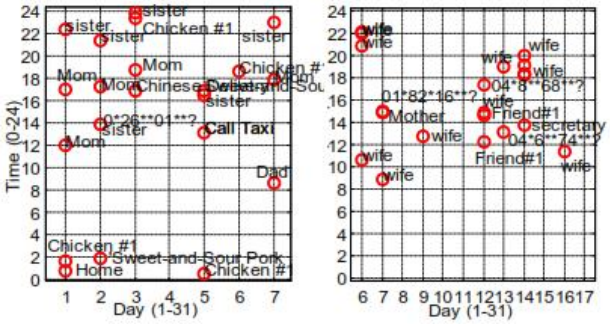

Figure 1. Example call maps: (left) a single, twenties graduate student and (right) a married, thirties man.

We also analyzed the call logs of 20 participants (20-40 Years old) for recent 3 months to see whether there is any Periodical pattern. Figure 1 shows 'call maps' which visualize all the outgoing calls on a graph with a time of day axis and a date axis. We could see that call maps do not only show calling patterns but also represent daily life patterns effectively. Calls in the left call map (twenties graduate student 'A') are distributed widely while calls in right call map (married thirties man 'B') are concentrated between 9 am to 9 pm and that on his wife. The visualization of the call map confirmed that we can recommend a number to call based on calling pattern of the user – the most recommendable number for person 'A' in the morning is 'Home', and the most recommendable number for person 'B' at any time is his wife.

DESIGNING CALL RECOMMENDATION ALGORITHM

A call recommendation algorithm selects numbers for an Search-call list based on the outgoing call logs. We chose 5 independent variables that can be a reason of recommendation day of week, weekend/weekday spans, time of day, day parts of a day, and 1-hour slots of a day as shown in Table 2. The algorithm calculates the probabilities of Bernoulli trials for each independent variable for each person in a phonebook and uses them to recommend numbers to dial.

Variables	Values
Day of week	Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday
Weekend /Weekday spans	Weekend, weekday
Time of day	3-hour periods (Current time ± 1.5 hours)
Dayparts (of a day)	Morning(6am-12am), Afternoon(12am-5pm), Evening(5pm-10pm), Night(10pm-6am)
1- hour slots (of a day)	Every hours

Table 2. Candidate values for 5 variables

For example, if a user presses the call button at 1:30 am on Mar 25th, 2008(example #2 in Table 4), the algorithm counts the number of days and the number of hours with a call to each person, and uses these numbers to estimate the Bernoulli probabilities. We examined how many times each

Variables	Occurrences with a call	Occurrences	Time scale	P'
Day of week	0	15 Tuesdays	24 hours	0
Weekend /Weekday spans	3	15 weekday spans	5 days * 24 hours	0.002
Time of day	5	90 3-hour periods around 1am	3 hours	0.017
Dayparts (of a day)	6	90 midnights	6 hours	0.010
1- hour slots (of a day)	6	90 day * 24 hours	1 hour	0.003

Table 3. Example of calculating probability to call

Condition occurs in the observation period to determine n_c (e.g. 90 times of 0am-3am intervals in 3 months). Number of cases k_{ic} with phone call to person i in each condition c make probability p_{ic} (e.g. $p_{ic} = k_{ic} / n_c = 5/90 = 0.056$) the probability p_{ic} here means that the user will make about 5 calls to person i at this time of day (0am-3am) for coming 100 days.

Every probability p_{ic} has different confidence level because of different n_c and standard deviation is $p_{ic}(1-p_{ic})/\sqrt{n_c}$. We calculate p_{ic} with pessimistic inference to reduce influence of noisy data (e.g. $p_{ic} = p_{ic} - std_{ic} = 0.05$). Because 5 independent variables have different time scales from 1 to 24 hours, we normalized p_{ic} into probability in unit time (1 hour). Then, the highest probability p_{ic} (Table 3) for each person in the phonebook were gathered and sorted. The algorithm then determines phone numbers with 5 highest probabilities and recommends them to a user with a reason c, for instance, "Because you called him/her most often at this time of day".

Rank	Example #1 2008/3/9(Sun.) 5: 24 pm		Example #2 2008/3/25(Tue.) 1: 30 am	
1st	Elder sister	(Time of day)	Food Delivery : Chicken #1	(Time of day)
2nd	Mother	(Time of day)	Home	(Time of day)
3rd	Home	(Dayparts : Evening)	Elder sister	(1- hour slots : frequent calls)
4th	Food Delivery : sweet-and-sour pork	(Time of day)	Food Delivery : Chicken #2	(Time of day)
5th	Food Delivery : Chinese restaurant	(Time of day)	Mother	(1- hour slots : frequent calls)

Table 4. Two example outputs of the recommendation

Table 4 shows two algorithm outputs generated at two different contexts for the person 'A' (left call map in Figure1).The algorithm generates different recommendations for the two different cases and explains the reason of difference. On Sunday evening, phone numbers of family members and food deliveries were recommended based on time of day. In the second example, the phone numbers of chicken delivery appears on the list because of his past orders around this time of day (the highest p_i =chiken c=time of day in Table 3).

CALL LOGS ALGORITHM

We could see that the calling patterns of users were very different. Some people concentrate their phone calls to a lover or a family member, while others distribute over different calls. Participants with a higher number of clicks and a lower hit ratio (group B, dotted lines in Figure 2) showed that the most frequently called call and top 3

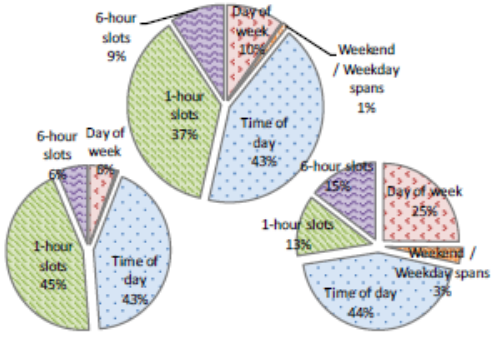

Figure 4. Reason of recommendations on success cases for all people (upper), for each group (lower)

calls comprise less than 20% and 40% of the entire calls, while other people (group A) made nearly 70% of calls to top 3 calls. Recommendations based on '1-hour slots' variable that reflects call frequency were reduced for group A as shown in the lower right pie chart in Figure 4. We expected that selecting different independent variables for the two different groups can shorten calculation time and produce better results. Then, the flow of our search-call list algorithm would become like the flow chart in Figure 5.

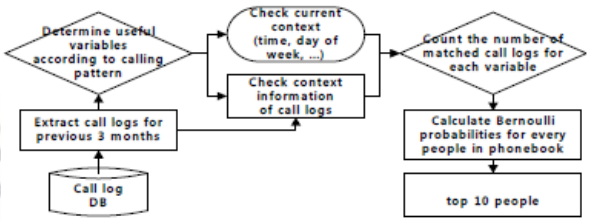

Figure 5. Data flow of adaptive search-call list algorithm considering the two different groups

To verify the effectiveness of the algorithm, we checked its recommendation outputs using "unseen" call logs. For instance, we asked it to predict callers for each call in the call logs of June using call logs from March to May. The algorithm could predict a correct called and include it in the search-call list. The usefulness of the recommendation was measured by the rank of the correct called in the list.

First, we compared the results with that of 'Searching' and 'Recent call list (RL)', which were shown to be two most popular call methods in our online survey with 75 users. In the latter case, a user was allowed to switch to a search page if there is no target in the list with 5 recent calls. The average number of click for searching was approximately determined by observing search process from 7 people using different phones. The average number of button clicks to make a call was 6.20, 4.33, and 3.80 for searching, using a RL, and using our search-call list, respectively. 3.80 clicks here mean an average recommendation rank of 2.80 (one click for 'SEND' button). Among 5 variables, '1-hour slots' and 'Time of day' were highly used for the recommendations.

Considering commercial products which can sort phone numbers with call frequency like BlackBerry, 'Frequency-based list (FL)' was added to the reference points in the 2nd stage of comparison. The average number of button clicks to make a call with call frequency based recommendation was 3.90 clicks. Also, first page hit ratios and top rank hit ratios were additionally compared because absence of a desired number on the first page makes us search the phone book, and the first item in the list can be dialed directly by two successive clicks of SEND button. The hit ratios for first page were 51.8%, 60.8%, and 62.5%, and the ratios of a desired number on the top were

30.3%, 36.6%, and 39.3% for RL, FL, and our search call list, respectively.

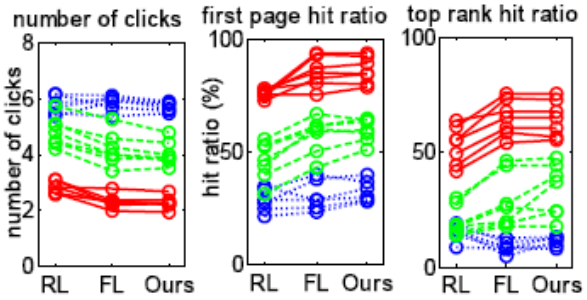

Figure 2. Individual mean comparison

All the average differences were statistically significant, and we also examined individual differences. Each line in Figure 2 shows individual means for the 3 calling methods. We could classify 20 users into 3 groups based on recommendation suitability. Recommendation algorithms including ours appear to be most applicable to group A shown with solid lines.

EVALUATION USING ESM SYSTEM

Our ESM system has architecture similar to Momento, and supports a real-time addition/modification of questions, an easy self report with a screenshot, and application logging for evaluating recommendation performance. Because we thought that the performance of our algorithm was verified in previous step, we used the ESM system to collect in-situ user feedback and experience about the usage of the search-call list, and did not attempted to use it to compare recommendation algorithms. The usual recent-call list page was replaced by our search-call list page with 5 recommendable numbers to call as shown in Figure. If the adaptive search-call list failed at recommendation, the user could change the list to the usual recent-call list, and opening the phonebook for search from the list page was also possible.

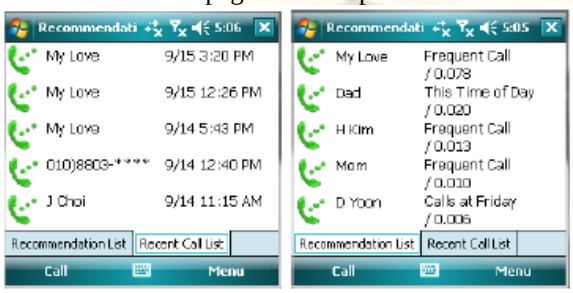

Figure 3 Usual recent-call list (left) was replaced by our Search-call list (right).

427 attempts to make a call using the search-call list were recorded as success by the ESM system. The average rank of the call in the list in the whole cases was 2.35. The search-call list failed to recommend a right call in 161 cases, and in 101 cases of them the call was not in recent call logs. We also calculated the expected recommendation rank of the calls for the outgoing calls that were made without using a search-call list. The expected average rank of the call was 9.27 (median 3) except newly dialed phone number during 3 months. Right after every call made by a search-call list, the ESM system presented a window to ask user feedback. 63.5% answered with 'helpful', 29.1% with 'not helpful', and 7.4% with 'no answer'. Some examples of subjective feedback were shown in Table 5.

A qualitative survey was done after the field study. Among the 10 participants, 8 reported that the call recommendation was helpful. All of them reported that the search-call list was helpful because of adequate candidates on the list, and half of them reported that they liked it because they did not need to type. Some participants were dissatisfied with the extra button clicks to invoke a search-call list; they had to press the call button and click 'call log' soft button on the screen again to see the list. The calculation process begins right after the user clicks the 'call log' button. If more optimized calculation starts in the idle time right after the phone is opened, this inconvenience would be reduced. We asked the participants about the requirements for this search-call list. "Fast switching to a search page or a recent-call list when recommendation failed" was elected as the most important requirement, and "fast calculation" and "accuracy" followed. In our implementation, recent call list was provided beside our search-call list as shown in Figure 3 and users could make a fast transition to each other with left and right arrow keys while up and down keys were used to select items on the list.

Was call recommendation helpful in finding the person to call?
I tried to call my boyfriend, and he was on the top of the list.
The person I want to call was the 1st.
It always shows a similar list, but is quite helpful.
I could see "home" when I was about to call home
I called someone many times recently, and the list helped me.
It was helpful (The recommendation seemed to be based on timeslots.)
I called him after a long pause, and the list was not useful. (*)
The time to call was reduced because of the list.
I looked up the number to call from phonebook. (*)
(*) marks opinions in not helpful cases

Table 5. Examples of subjective feedback

CONCLUSION

We studied mobile phone users' calling patterns, designed a search-call list algorithm for an speed search list using the time based, and evaluated it with an ESM system. Our method was shown to be effective in terms of the number of button clicks to call, hit ratio for first page and top rank item in the call list compared with other common methods. In-situ responses through our ESM system helped us confirm that the search-call list was helpful and also pointed out many problems to improve. Considering individual differences in calling patterns is expected to improve the accuracy of call recommendation.

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