Evaluation of Human Altruism Using a DTN-based Mobile Social Network Application

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Abstract: Advancement in mobile computing and smartphone proliferation has enabled mobile devices to support a richer range of services besides calls and texting. Recently there has been a lot of focus on developing human centric mobile social applications to perform collaborative social activities for mobile users in highly distributed environment, such as photo and information sharing, and proximity-based communication. However, the success of these applications relies on selfless and altruistic participation of individuals (i.e. mobile users).

In this paper we develop DMS, a resource-aware delay tolerant network (DTN)-based mobile social network application to get a better understanding of the altruistic nature of human behavior. We study how limited resources like battery can affect the user's behavior toward the mobile application with varying levels of scrutiny in lab and daily life environment.

1 Introduction

In today's era mobile phones become ubiquitous in our daily life. With the proliferation of smartphones a vast majority of individuals carry small devices that not only provide a means of communication, but are also equipped with storage and computational resources. Such development in mobile computing has envisioned a future with human centric mobile applications and development of mobile social applications in a distributed environment. For instance PeopleNet [MS05] leverage a mobile application to seek information in a mobile social network environment. Prism [DMP$^+$10] is a remote sensing architecture in a mobile society using smartphones. The Reality Mining experiment [Lab10] studied communication, proximity and activity information from 100 subjects in MIT.

The success of mobile based social applications largely relies on resource sharing and selfless/altruistic human contribution. However, there is little real deployment data available which sheds light on the human beings' altruistic nature when they use mobile social applications to share scarce resources altruistically.

Altruism, trust and incentive studies are much related to what is happening in the field of behavioral economy. Researchers in that field use popular games like prisoner's dilemma, dictator and ultimatum to observe human behavior under different choices [Lis07]. These studies are very limited, artificial and the conclusions are unreliable. This is because the experiments are conducted in a lab environment and subjects tend to behave nicely under influence. In a similar fashion, paper based surveys are used to get an idea of how people feel about different applications, but since they lack real deployment the results are also unreliable and artificial.

Vallina-Rodriguez et al. [VRHC09] conducted a paper based survey to understand how people feel about using DTN technologies. The results show that 45% of the subjects surveyed are willing to share their resources (e.g. battery, memory and CPU) if they can get benefits from the collaboration. 33% of the subjects questioned agreed to share their resources in an altruistic manner. However, one cannot completely rely on these results, as the survey may have been affected by scrutiny of the surveyor according to Levitt and Lists behavioral model [LLB+06]. This behavioral model predicts that the absence of anonymity will be associated with an increased level of pro-social behavior relative to settings in which individuals are more anonymous.

In this paper we present DMS, a resource-aware DTN based mobile social network application capable of micro-blogging and messaging by utilizing mainly close range communication via Bluetooth. DMS is built with the functionality to monitor and allocate battery power as per the user's desire. Battery is still a scarce resource in mobile world and serves as a limiting factor on usability of a mobile phone. We use DMS to evaluate the altruistic notion of human behavior when it comes to sharing battery under varying levels of scrutiny.

This paper follows the approach of List [LLB+06] by conducting studies in the lab and in the field to study the effects of scrutiny on the subjects. The study also makes an attempt to answer the questions posed byVallina-Rodriguez et al. [VRHC09] about how many people really do act in an altruistic manner and how the state of the handset resources affect the subject's decisions to share.

The experiment starts in a lab environment where the subjects are introduced to a paper based survey/questionnaire (see Appendix A.) to fill out their resource (battery in our case) sharing preferences under supervision. Next, the subjects are introduced to the mobile application with a demo account. Finally, the subjects create a real account and participate in a week long real experiment. The mobile phone application is used without supervision and the subjects may change their preference any time. After the experiment, we compared the results of the paper based questionnaire with real life experiment to see how the subjects behave with and without scrutiny i.e. whether the subjects act more or less altruistically in the real environment without supervision.

Although our datasets cannot be more extensive for the initial experiment, we believe these measurement results offer us one step closer towards a better understanding of the human altruistic behavior in mobile social applications.

2 DMS: DTN based Mobile Social Network Application

DMS is a DTN based mobile social network application developed on top of Goose [ZHC+11]. Goose is a Social Network Service architecture developed for low end Symbian based Nokia phones and mainly utilizes close range communication via Bluetooth for propagating messages. The primary objective of Goose was to provide social communication like microblogging, messaging and friend searching in developing region. It also supports one-to-one communication like sending text or voice messages to a friend by using common wireless network facilities i.e. GSM and Bluetooth.

DMS extends the functionality of Goose with three additional managers and parallel to Symbian the application is also ported on Android OS. The popularity of Android being the market leader (with 50.1% of market share [Com12]) and the readiness of the API called for the porting to be done so more subjects could participate. The port required some modifications to the user interface, implementation of encryption and device pairing on both platforms in order to allow cross platform communication.

DMS supports data transmission in unicast, multicast and broadcast mode. Short messages and contact information are sent in unicast mode via direct forwarding strategy. If a message has a high priority and a direct Bluetooth connection is not present DMS will use GSM (SMS) network, provided the user is ok with it. Friendship searching information and group messages are sent by multicast. Broadcast mode is configure to work on Bluetooth only, and the epidemic routing strategy [CHC+] is used to send the message to the whole network. With epidemic routing each node stores messages to be sent in its buffer, carries them, and sends the message to the nodes when it encounters, based on the Bubble Rap algorithm [HCY11].

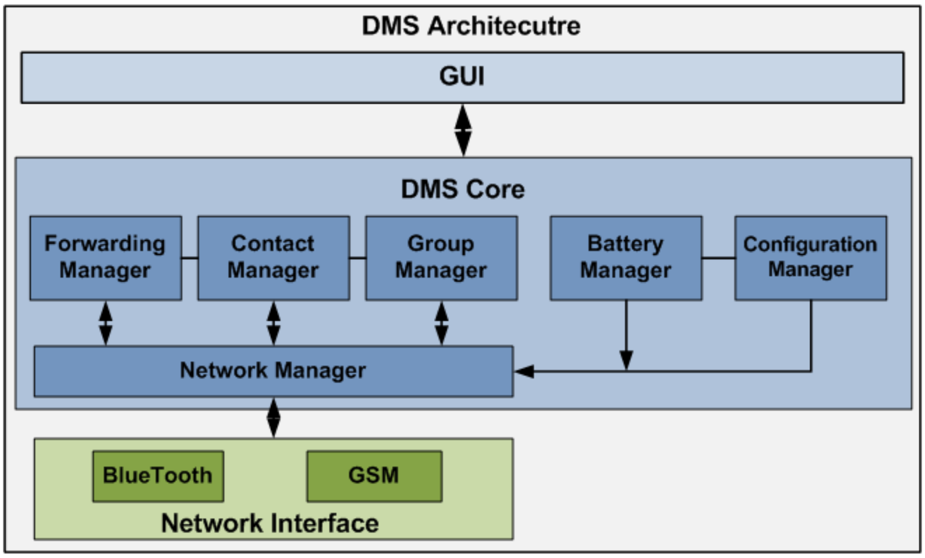
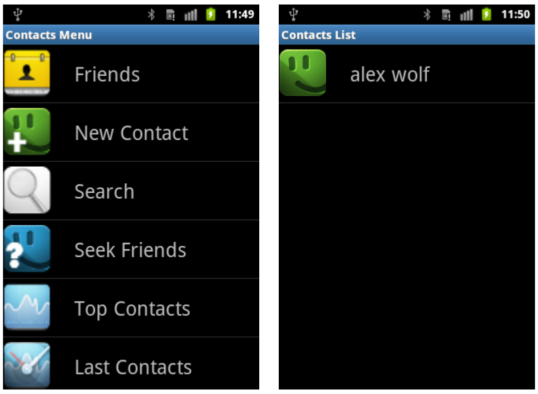


Figure 1: DMS Architecture

DMS consists of three parts i.e. the GUI, the network interface (Bluetooth, GSM) and the DMS Core. The DMS Core controls six managers that provide the main functionality to DMS (see Fig. 1). Contact, Forwarding and Network managers are already implemented in Goose and DMS extends Goose with Battery, Group and Configuration managers. Following is the listing of all the managers with their functionalities.



(a) The Contacts Menu (b) The Contact List

Figure 2: Contact Management Interface on Android OS

2.1 Contact Manager

Contact manager stores contact information of the user (e.g. name, phone number... etc.) in the database. This is helpful in selecting the recipient's contact for creating new message, identifying nearby devices, and retrieving the sender of a message. It also records the Bluetooth MAC address for communication.

2.2 Forwarding Manager

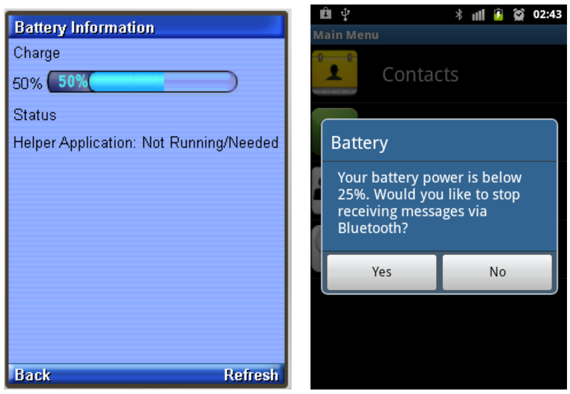
Forwarding manager is use for forwarding the messages. It keeps a record of the message based on their unique ID and MAC addresses to avoid retransmission. It is also responsible to periodically check if friends are in range to forward the message. Once a message reaches its TTL, it is not forwarded any more.

2.3 Network Manager

Network manager controls and coordinates the network interface to send and receive data via Bluetooth and GSM. It scans for the nearby Bluetooth devices to exchange messages and friend requests to buildup social relationships. It is also responsible for switching between Bluetooth and GSM based on the connection situation and message priorities.

2.4 Battery Manager

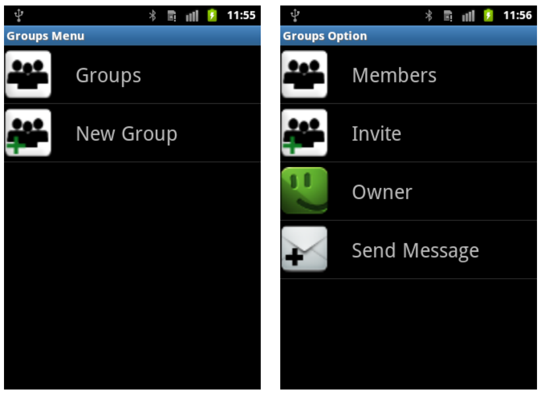
Battery manager allows system wide access to the battery status information. It is responsible for keeping track of the battery charge value and the power status of the phone. This enables battery level based user notifications and logging of battery levels with respect to time. The battery charge is measured in percentage from 0 to 100%. The power status may change between ”charging”, ”powered by battery” and ”plugged in to charger”. Battery monitoring is implemented natively for Symbian OS to keep track of the battery status. Naturally this functionality is also added in Android but contrary to J2ME, it is part of the Android API.



(a) Battery Monitoring interface on Symbian

(b) Notification dialog triggered on Android OS

Figure 3: Battery Monitoring interface and Notification dialog



(a) Group Menu

(b) Group Option

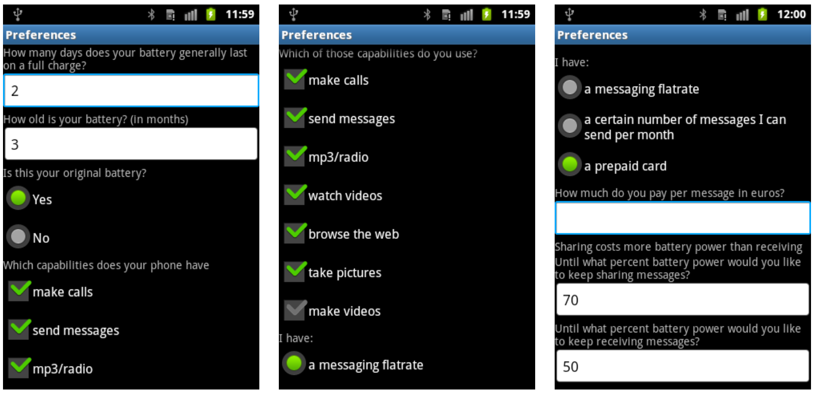
Figure 4: Group management interface on Android OS

2.5 Groups Manager

Group manager is responsible for creation and management of groups. The message sent to a group, is sent to a predefined list of people. This feature is comparable with a shortcut for selecting a subset of contacts from the contacts list to send a message to, with the exception that the list is managed by the group's owner.

2.6 Configuration Manager

Configuration manager manages the user preferences regarding different settings for DMS usage. This also includes the battery usage and resource sharing preferences. The user has to explicitly specify until what battery level percentage the subject would like to share the device as a relay and until what battery level percentage the subject would like to receive messages from other devices. This plays a vital role in the battery monitoring process because the preference set by the user affect behavior of the handset i.e. whether or not to continue scanning for devices and whether or not to turn off receiving. First time users have to set the preference before starting the application and after that the preferences can



(a) (b) (c)

Figure 5: Scrolling down from the top (a) through (c) display the choices to be made in the Preferences Menu

be edited anytime.

3 Experimental Setup and Deployment

The main focus of the study lies in the altruism displayed by the subjects when they act independently and under scrutiny. In this section we explain how the experiment was set up and deployed.

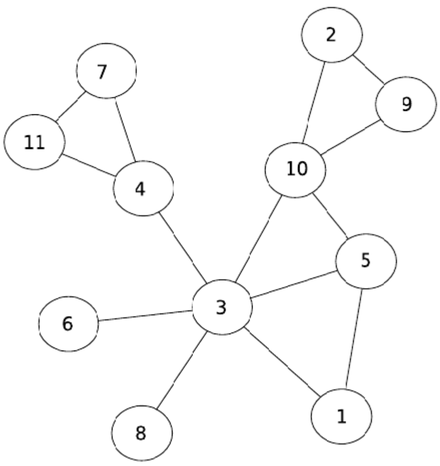


Figure 6: Social network of participating subjects

3.1 Setup

The experiment is carried out roughly for 8 days during which around 11 subjects participated. The subjects are all students ranging from bachelor to PhD programs with age ranging from 21 to 34 years. The social network of the subjects is depicted in Fig. 6 where the subjects that know each other and come into contact are connected with lines. Subjects may or may not know or come in contact with other subjects not connected with lines.

Prior to the experiment, the subjects are instructed to fill out a paper questionnaire (see Appendix A.). The questions asked, pertained to phone/battery usage, battery longevity, battery age, features of the device and willingness to relay messages by actively ”sharing” the battery power. The subjects fill out the questionnaire (which is exactly the same as the preference settings in Fig. 5) under supervision to introduce scrutiny.

Once done with the questionnaire survey the subjects are free to start using DMS and set their custom preferences without any scrutiny. When it comes to sharing a scarce mobile resource like battery the subjects can set their preferences to participate in three states;

1. **Sharing and Receiving :** The normal mode DMS starts in.
2. **Only receiving :** Once the battery reaches a preference mark, DMS will stop forwarding the messages and scanning is turned off.
3. **Not participating :** Upon reaching the second battery level set by the subject, DMS will stop receiving messages and turns off the Bluetooth. Once the subject will recharge his smartphone battery, DMS will reactivate sharing and receiving of the messages.

3.2 Deployment Issues

As with all the experiments, finding subjects to volunteer was difficult. The participants were required to have a Nokia or Android smartphone. During the experiment a variety of models were used, such as Galaxy S, Galaxy S2, Galaxy Gio, Galaxy Ace, Galaxy Nexus S, and HTC Wildfire (majority of participants have android phones). Due to variety of hardware, deploying DMS was difficult the first time. Fortunately subjects were patient and lent their devices for testing and debugging. After these tests, software robustness and usability increased.

3.3 Data Collection

At the end of the experiment, we collect the data from 11 subjects. For privacy reasons we kept the identities anonymous and for the messages we only recorded the message IDs and time. We also recorded time stamped records of the battery level, phone calling function, wireless adapter state, GPS state, cell tower associated with number of friends encountered, messages sent or received, if sharing or receiving is turned off, and if DMS is turned off and why. All the data is written to an encrypted text document on the external storage card.

4 Evaluation

In this section we briefly present the functionality evaluation of DMS, like performance evaluation of battery life in an isolated setup and the usage activity of DMS during the experiment. We then move on to the main focus of this study i.e. the altruistic behavior of the subjects in sharing their smartphone resources for relaying messages and compare it with the preference they filled out in the paper questionnaire.

4.1 Performance of Battery Life

After building and debugging DMS extensively on both platforms (Symbian and Android), we evaluate the performance of battery life on the Android platform (as 10 out of 11 subjects carried Android phones). We used Samsung Galaxy Ace running Android 2.3.3 and performed 4 different tests (with 100% charged battery) as follows.

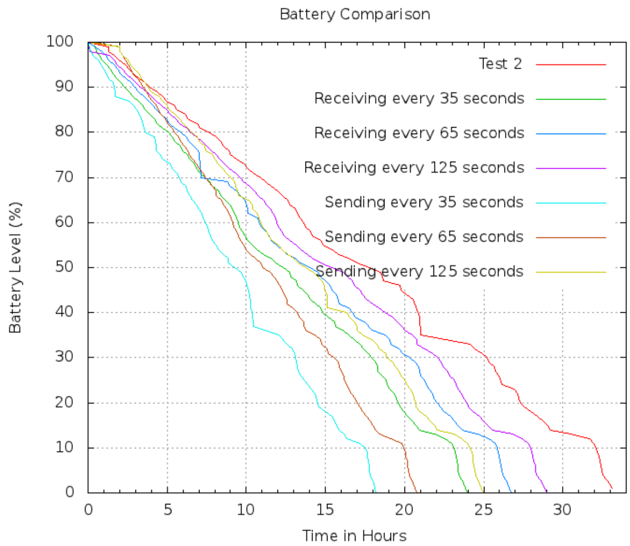


Figure 7: Performance of Battery Life on Android Platform

Test 1 - Normal Operation

During this test the device remained idle with no application running. Under these conditions the battery lasted 10 days 2 hours and 12 minutes before it shut down on its own due to battery depletion.

Test 2 - Only DMS

During test 2 the devices only ran DMS i.e. no message was sent or receive. Running DMS uses a partial wake lock that keeps the processor and the Bluetooth radio running while the screen and the keyboard may turn off. There was no Bluetooth interaction other then the device own scanning every two minutes. The battery lasted 33 hours 5 minutes and 12 seconds.

Test 3 - Receiving Messages

In this test, the battery was monitored to measure the impact of accepting connections and receiving messages. We placed a second device (one meter apart) with a modified version of DMS to send a message of 1 MB to the test device at an average interval of 35, 65 and 125 seconds. The battery lasted 23 hours 58 minutes, 26 hours 44 minutes and 28 hours 58 minutes for the message intervals of 35, 65 and 125 seconds respectively.

Test 4 - Sending Messages

In this test the battery was monitored to measure the impact of sending messages to another device. DMS was modified to send a new 1Mb sized message every 35, 65 and 125 to the same host repeatedly until the device turns off. The device's battery lasted for 18 hours 12 minutes, 20 hours 45 minutes and 24 hours 58 minutes for the message intervals of 35, 65 and 125 seconds respectively.

Normally sending a message is more battery hungry function, since it requires the Bluetooth radio to be actively powered by the battery to emit electromagnetic waves [FKK11]. Comparatively, the receiving end is only confirming the received data. As a minimum requirement it was envisioned that the device should last at least one day when DMS is running on it as any application that drains battery power quickly will not be enjoyed for long. DMS running on an Android device is able to last at least one day (16 hours) even under stress. Android will normally encounter traffic similar to or less than what is seen in test 3 and 4 because scanning and transferring of messages is done in cycles of 2 minutes.

4.2 Battery Charging Behavior

Battery manger is able to log various battery events which helped us understand the battery usage and charging pattern of the subjects. On average the subjects used to charge their phones every 16-24 hours. However, some subjects with very high device usage (calls, video and multimedia) even charged their phones 2-3 times a day. Overall, the average battery levels for all the subjects remained between 10-90%. Throughout the experiment we only noticed one instance where the battery level touched 0%. Apart from calls, Wi-Fi was actively used among all the subjects, indicating easy access to Wi-Fi connection at the university campus and workplace.

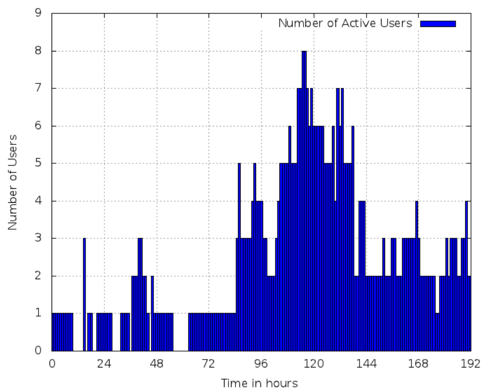


Figure 8: User activity over the course of the experiment

4.3 User Activity

The user activity over the length of the experiment is depicted in Fig. 8. The bar indicates the number of users simultaneously using DMS and the max number of active users at any time are recorded to be 8. User activity follows a certain pattern. Most of the subjects used the application at their workplaces during second half of the day from 12:00 to 18:00 O'clock. Overall it remained quite over the weekend since there may be no encounter among the work colleagues.

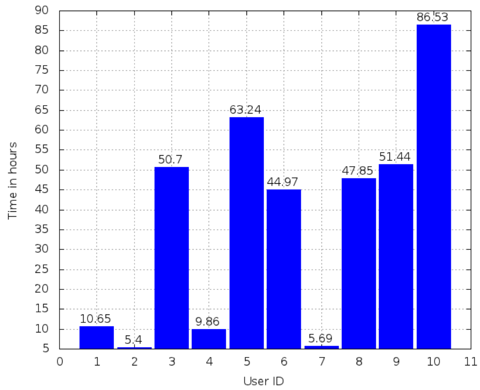


Figure 9: Total number of hours DMS was used

4.4 User Sessions

Fig. 9 shows the total number of hours DMS was used by each participant. Subject 10 used DMS the most for approx. 86.5 hours, whereas, Subject 2 used it the least (5.4 hours) throughout the experiment.

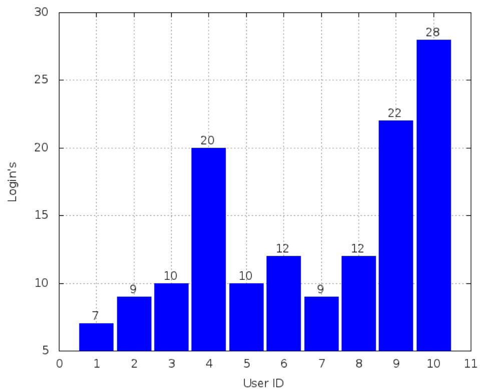


Figure 10: Total number of times DMS was started

Fig. 10 displays the number of sessions/logins. Some subjects started DMS frequently over the course of the experiment while others remained inactive. In some cases the unreliability of Bluetooth often required numerous restarts to achieve communication between the devices. The amount of time spent by the subject is an indicator of their motivation (usefulness, willingness) to use the mobile social application.

4.5 Altruistic Evaluation

Altruism is defined as a user behavior that lowers one's own fitness for the benefit or good of others. Before we go into evaluating the altruistic notion of human behavior in mobile social networks, the parameters of altruism must be defined. Now a days smartphones are equipped with reasonable memory and computational power, however, battery is still a scarce resource. In order to increase utility, a user must keep a check on the number of application running on his smartphone to conserve battery power.

Within the scope of this study fitness is measured in terms of battery level percentage and altruism is a behavior that lowers one's own fitness to strengthen other members. Therefore, sharing more battery than what the subject themself previously defined as acceptable during the survey should be considered lowering their own fitness for the good of their friends. To define which actions are to be considered altruistic behavior, we set three basic guidelines as follows:

1. Lower the battery sharing threshold for longer usage of the DMS application.
2. Keep the application running even after the threshold (set previously to the subject's own specifications) had been reached.
3. Continue using DMS, even if it is of little importance to the subject.

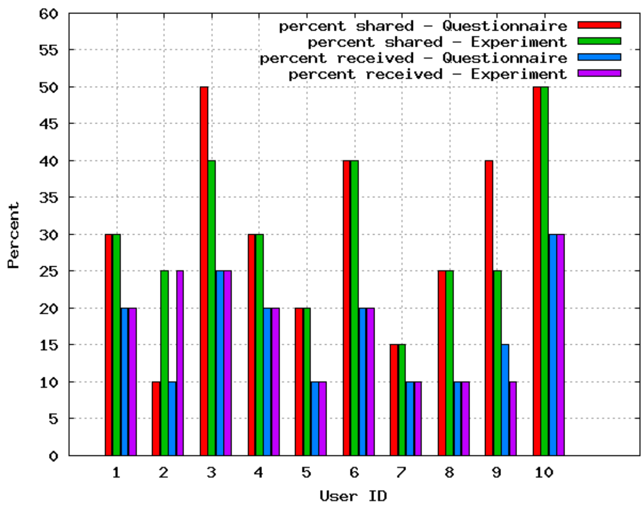


Figure 11: Comparing what subjects predicted they would do to what they actually did

When it comes to lowering the battery threshold, around 20% of the subjects acted altruistically and shared more battery resources. 10% lowered the battery sharing by increasing the threshold. Fig. 11 shows a comparison of predicted behavior of the subjects in the questionnaire with actual behavior during the experiment. Subjects 3 and 9 changed their initial sharing preferences (compare red to green bar) in an altruistic manner from 50% to 40% and from 40% to 25% respectively. Subject 2 on the other hand increased the threshold from 10% to 25%. Preferences of all the remaining subjects remain unchanged.

In Fig. 12 and 13 we have switch the axis of Fig. 11 and separated the preferences of sharing from receiving between the values chosen in the questionnaire and software in a clear manner. Fig. 12 reveals that the settings used for the software was changed at the 10% and 50% regions to 25% compared to the paper questionnaire.

According to the results, none of the subjects kept relaying or receiving messages once the threshold battery levels set in the preference were reached. This may be because most

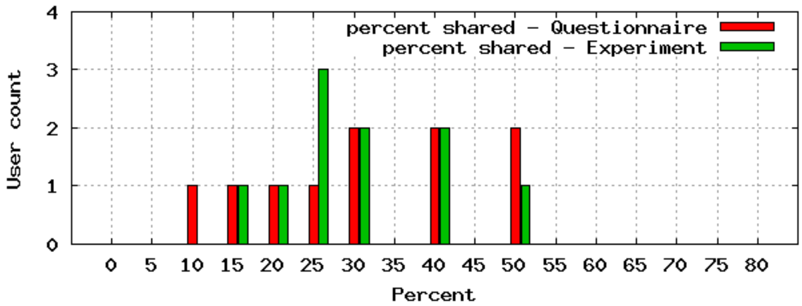


Figure 12: Comparing what subjects predicted they would share to what they actually shared

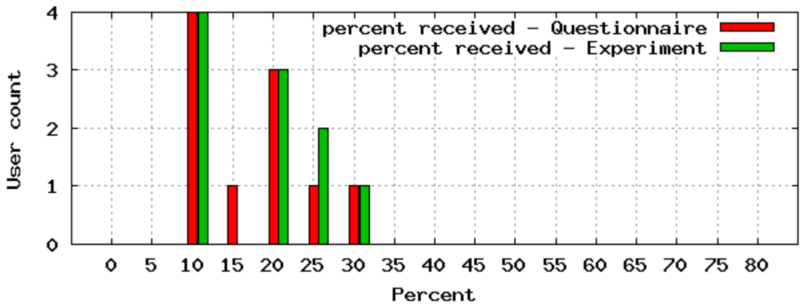


Figure 13: Comparing what subjects predicted as their receiving level to what they actually set as receiving level

subjects are not really aware of their battery power levels throughout the day and react only to the warning of the phone. Like in Android system a warning is issued when the battery level reaches 20% during normal operation and subjects are used to charging their devices at that point. For some, the battery level never reached the levels they defined in the preferences, resulting in application to run continuously.

We also find out that around 30% of the subjects had very high session duration compared to number of messages they sent and effectively got very little use for running DMS. Overall the average ratio between number of messages sent compared to the total session time remained below 0.5 which is good.

Levitt and Lists [LLB$^+$06] model predicts more selfish behavior from people in more anonymous situations. Based on the results presented in this section, 20% of the subjects acted more altruistic even in the absence of supervision. This indicates that the systems that are pro-social influence the user behavior to be more altruistic even without scrutiny. A minor downside in our datasets is that it cannot be more extensive for the initial experiment. Still we believe these measurement results offer us one step further towards a better understanding of the human altruistic behavior in mobile social applications. There is indeed a need to know people's behavior to build better application. As part of the future work we are focusing on increasing the user base significantly with more random selection that can generalize the society.

5 Conclusion and Outlook

In this paper we presented a resource-aware DTN based mobile social application (DMS) and used it to evaluate the altruistic behavior of the subjects when it comes to sharing scarce resources like battery. During the evaluations we compared the results of paper based questionnaire with real life experiment. The motive here was to find out how the subjects behave with and without scrutiny i.e. whether the subjects act more or less altruistically in the real environment without supervision.

The results show that only 10% of the subjects behaved more selfish in conditions imposing less scrutiny. However, there was an overall increase of pro social behavior in the field compared to paper questionnaire and 20% of the subjects acted in a more altruistic way by sharing more resources (battery) to strengthen the network. This varies from Levitt and Lists model [LLB+06] of scrutiny which hypothesized that lack of scrutiny increases selfishness and reduces altruism. In the end we can say that the results in this paper are encouraging for mobile related applications that intensively rely on resource sharing and human contribution.

Future studies in this domain will focus on increasing the number of participants with more random selection to represent the society in a better way. Further, we plan to make DMS more aware of the available resources like CPU, memory and battery. This will help the mobile user to take full control on the sharing of a perticular resource to the granularity of their choice.

6 Acknowledgements

We would like to thank the volunteers who participated in the experiments and the anonymous reviewers for their helpful comments. We would also like to thank Dr. Pan Hui (Deutsche Telekom Labs, TU Berlin) for his valuable feedback during the development and porting of DMS on top of Goose.

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A Survey Questionnaire

Thank you for taking part in the experiment. Before you start using the application please fill out this short questionnaire about your phone and battery usage.

1. How many days does the battery in your phone generally last? ——-
2. How old is your battery in months? ——-
3. Is this the original battery that came with your phone?
   (a) Yes, this is my original battery.
   (b) No, I have acquired an alternate battery.
4. What capabilities does your phone have?
   (a) Make Calls
   (b) Send Messages
   (c) Listen to Music and/or Radio
   (d) Watch Videos
   (e) Browse the Web
   (f) Take Pictures
   (g) Make Videos

5. Which of the capabilities that you checked, do you actually use?

    (a) Make Calls
    (a) Send Messages
    (a) Listen to Music and/or Radio
    (a) Watch Videos
    (a) Browse the Web
    (a) Take Pictures
    (a) Make Videos

The application used for testing will use battery power at an increased rate compared to when you normally use your phone because it uses your Bluetooth radio to scan for nearby friends to receive from and share messages with. You have the option of turning off scanning when you have a specified amount of battery power left and the option to turn off receiving when you have an even less specified amount of battery power left.

6. Until what percent battery power would you like to keep sharing/forwarding messages for friends? ——-

7. Until what percent battery power would you like to keep receiving messages? ——-

8. How old are you? ——-