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Privacy Concerns in Sharing Personal Consumption Data through Online Applications

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***Abstract*—As online eco-feedback social applications are being increasingly used around the world for motivating citizens to become more energy-aware, privacy concerns in terms of sharing personal electricity consumption data among online contacts are rising. Through Social Electricity, an online application offering personal energy management through a social and collaborative environment, we study the privacy concerns of the users in two case studies, in Cyprus and Singapore. For the Cyprus case, we present an analysis of results gathered through a large questionnaire-based survey combined with mini focus group studies. For the Singapore case, we analyze the findings collected through a students' semester exercise. This paper provides interesting insights about the overall acceptance and tolerance levels of users of eco-feedback social applications.**

***Keywords*—Privacy; Users Perceptions; Energy Awareness; Social Electricity; Online Social Applications; Eco-Feedback.**

I. Introduction

Various eco-feedback applications are being around the world more and more [1], [2], [3], [4], [5], aiming to encourage people to become aware about the environment, and to engage in more sustainable practices.

As users tend to be influenced by their online friends, online social networks have become effective channels in motivating people towards obtaining more sustainable behaviors [1], [2]. Besides, strong participation in sustainable actions is most likely when activities can be easily integrated into daily life [6], as is the case with online social networking today [7].

However, by exploiting online social networks, people's personal consumptions become exposed to their online contacts. This creates large privacy implications, as users share sensitive data that may reveal information about their personal life and habits. These implications led many people in the aforementioned applications to be reluctant to participate. Hence, special care needs to be taken by such eco-feedback online applications, to respect the privacy of users, without reducing the effectiveness of various eco-feedback services offered by them.

This paper builds upon the development of Social Electricity [8], [9], which is a large-scale ICT application targeting energy awareness of citizens by means of social and local comparisons of electricity among online contacts, in order to study the results of two user studies, in Cyprus and Singapore, related to users' perceptions on the acceptance and privacy of the presented approach, aiming to shed light into the personal and social dimensions that shape privacy concerns of people when engaging with online eco-feedback social applications. Although the main research goals of these case studies did not target privacy [10], [11], through these studies we acquired important feedback related to the privacy concerns of the participants, which are important for understanding the overall acceptance and tolerance levels of users of eco-feedback social applications.

The rest of the paper is organized as follows: first, we review related efforts in this field. Subsequently, we present Social Electricity explaining the methodology followed in the conducted user studies in Cyprus and Singapore. Then, we provide some insights in regard to privacy concerns of the users of the application and, finally, we summarize the paper discussing future work.

II. Related Work

The effort to understand the privacy requirements of users in regard to sharing their energy figures is the main contribution of this paper, since tenants generally worry about their privacy [12]. Our work is one of the first, to our knowledge, trying to understand and illustrate these user concerns by means of a real-life, large-scale user study.

Related work in this area includes the work of Ahern et al. [13], which reveals common themes in privacy considerations regarding online photo sharing, and the work in [14], studying user preferences for balancing awareness with privacy in an application called mySpace.

Concerning approaches to increase privacy, Yuksel et al. [15] propose an approach based on the grouping of friends, with

the assumption that friends share the same information with other group members. They use standard clustering techniques, surveying the users by asking them questions that would reveal their willingness to share information with others in their social network. Similarly, the authors in [16] introduce a mechanism that assists users in grouping their friends according to traditional group based policy management approaches. They introduce a new privacy management model that leverages users memory and opinions of their friends.

Fang and LeFevre [17] outline an approach, using machine learning, to describe a user's privacy preferences. In essence, they build a training set by asking the user to label (allow or deny) a subset of friends relative to a specific object. The training set contains friends' specific attributes such as age, gender and social network community.

Finally, the need for control over how people share information online is discussed in [18], posing challenges and presenting systems which try to meet those challenges.

III. Social Electricity Eco-Feedback Application

Social Electricity is an online application that allows people to perform comparisons of their electrical consumption with their online friends, neighbors in the area where they live, and other online peers. It constitutes a complete personal energy management tool, through which users can share their electricity consumption information[1] with others, towards better perceiving their personal footprint, exchanging information and experiences, towards the co-creation of knowledge and energy savings. More information about the application is provided in related work [11], [10], [9]. Social Electricity is also available online for all citizens[2] around Europe, designed and developed through the SEOP[3] EU project.

Social Electricity offers the following privacy features, which have been available to the users of the case studies in Cyprus and Singapore:

1) Option to select a nickname instead of real name in comparisons with other users.
2) Option to hide the exact address on the map-based geo-visualizations and show only general random location inside the city.

No option to completely hide personal electricity consumption information was provided to the users, and this was done intentionally, in order to examine their reactions in terms of privacy.

IV. Methodology

In this section, we present the methodologies used during our user studies in Cyprus and Singapore, with a focus in this paper on investigating users' perceptions relating to their acceptance and privacy concerns in using Social Electricity. More details about the methodologies used are provided in related work [11], [10].

[1]Electricity consumption information is added to the application monthly, unless users have smart energy monitors installed at their homes.

[2]Social Electricity. http://www.social-electricity.com/

[3]SEOP Project. http://seop-project.eu/

	Male	Female	18-24	25-34	35-49	50-64
N	126	72	62	97	32	7
%	63.6	36.4	31.3	49.0	16.2	3.5

TABLE I. Demographics of the participants: Cyprus study.

	Male	Female	18-24	25-34	35-49	50-64
N	59	116	157	15	0	0
%	33.7	66.3	89.7	10.3	0	0

TABLE II. Demographics of the participants: Singapore study.

A. Methodology in the Cyprus Case Study

At first, an online questionnaire consisting of 32 questions was conducted to collect empirical evidence on the usage of the application. A five-point Likert scale was used to rank the level of importance from "Not Important (1)" up to "Most Important (5)", while some questions had a "Yes/No" answer pattern. The participants were recruited by sending an invitation through email to users who were using the application for more then two months. The response rate for the questionnaires was around 16%, a total of 198 people. The distribution in age groups is depicted in Table I. Males were the majority of the sample (63.6%). The most popular age group was 25-34 years old (N=97, freq=49%), mostly young couples.

Secondly, semi-structured mini focus group sessions [19] were conducted with the participants' subjective preferences and perceptions. We recruited participants by asking users who participated to the questionnaire whether they would be willing to participate as well to subsequent focus group studies. The focus group participation was about 5%, and we selected those who fitted better to our target categories (see Section V-A2). The themes under discussion were selected after the analysis of the questionnaire, focusing on various concerns about privacy. The sessions have been directed by one objective interviewer and lasted 50 minutes, being audio-recorded by one observer.

B. Methodology in the Singapore Case Study

The case study took place during the spring semester of the National University of Singapore, involving 175 students from two different undergraduate courses offered by the Department of Building: PF1105 (Intelligent Buildings) and PF3303 (Facilities Management). The use of Social Electricity was assigned to the students as a semester project. Table II lists the demographic characteristics of the students.

To motivate students to actively participate in the exercise, we graded their overall participation with a 5% bonus on their final grade. In order to get this bonus, they were instructed at the end of the semester to prepare a final report, explaining whether and how they used the application, including their feedback on privacy implications about sharing their personal electricity consumption.

V. Analysis of Results

Here we describe the results from the two user studies, gathered through the survey and focus groups in the Cyprus case, and the final reports of the students in the Singapore case.

A. Analysis of the Cyprus Case Study

The analysis for the Cyprus study involved both a questionnaire and two mini focus groups. We present the analysis of their findings below.

1) Questionnaire: The research questions of the questionnaire in relation to users' privacy are listed in Table III, together with the responses from the participants.

From the participants, 77% believe the application respects their privacy. The rest 23% have some concerns about the overall privacy, e.g. that their personal consumption could be revealed to third parties. However, 60% of those having concerns declared willing to share their consumption with people they trusted. Also, from this group of users, 59% were positive to share with their online contacts only some indicators of their personal consumption (e.g. daily/weekly peak, minimum, maximum or average consumption, energy savings achieved). This is an interesting perspective for comparisons involving other people.

Overall, 85% are willing to share their *personal* consumption with their online friends. From the rest 15%, people are reluctant mainly as they consider those data strictly private, but also for not trusting all of their online contacts. Less popular reasons are worries of being exposed to thieves (e.g. by knowing when they are away from home) and to avoid the possible curiosity of the public about one's consumption (e.g. sometimes large consumption is an indication of wealth).

More than half of users (59%) would feel more comfortable if the sharing of consumption data involved street/neighborhood data instead of personal consumptions. However, most users recognize that this would result in less effective and meaningful comparisons. A percentage of 42% are worried with the possibility that their personal data could be revealed to third parties. This implies that organizations offering eco-feedback services need to build a high level of trust between them and their users.

Concerning specific features of Social Electricity, users have most concerns for displaying personal consumption data as well as showing the exact location where they live on the map. Displaying street location data or consumption raises less concerns, while sharing personal historical data is considered of average significance in terms of privacy.

Obviously, a considerable group of users classify privacy issues as important in terms of sharing their electrical consumption among their friends. To identify the "tolerance levels" of our users in regard to sharing electricity data, we asked them whether they would share their consumption figures with people they trusted, and with whom they would be willing to share the consumption of their neighborhood, that of their house as well as the detailed consumption of their household electrical appliances (see Table III, questions 12-14). The different user categories for sharing were: only me; family members; relatives; close friends; all friends; and everyone. Their answers are depicted in Figure 1. The graphs are interpreted as follows: starting from "only me" and ending to "everyone", each category is a superset of the previous one. For example, sharing personal consumption with relatives, this means that the user agrees to share also with his family members and himself.

As the results show, users have different sharing preferences, depending on how personal the data are. While 19% are willing to share their neighborhood's consumption with everyone, they are reluctant to do this with their home's consumption, or the consumption of their appliances. In this case, they prefer to share it only with family members, relatives and/or close friends (aggregated 88% in home level and 77% in appliance level).

A large percentage (30%) trusts only the other members of their family for sharing their detailed consumption, while only a smaller percentage (14%) wish to share their consumption at appliance level with close friends. Apparently, some users do not trust their close friends, in order to share with them their personal footprint. This percentage is increased in house (36%) and neighborhood level (41%).

it is remarkable that from the general to the more specific consumption data, an increasing percentage of users trust only themselves for viewing these values. This percentage starts from 5% in neighborhood level and increases up to 17% in appliance level.

Finally, we asked the participants if the proposed user categories for sharing are adequate to them or they wanted to suggest some more. Some users suggested the categories of "colleagues" (9) and "business contacts" (6). Many users asked to manually select one-by-one with whom to share their personal data (17) while two users proposed sub-categories below the main categories, for example for selecting only some trustworthy contacts from the list of close friends/relatives.

2) Focus Groups: Focus groups were conducted to validate the results from the online questionnaire, and focus more on issues of ambiguities among the participants. The groups were divided in two categories, selected in a way to best represent our users. These categories represent the majority of our users (75%). Each category included seven people (4 male - 3 female):

- Students (18-24 years old) who live with their parents and do not pay any electricity bills.
- Citizens who live and work in the country (26-32 years old).

We will refer to the former group as *students* and to the latter as *citizens*. For better results, we initially performed a pilot focus group, consisting of university students.

As privacy seems to be high in the agenda of both group, it created a fruitful discussion among them. At first, we asked both groups to discuss on the overall privacy of Social Electricity.

Students agreed that the application respects their privacy in general, but asked for more control over the sharing of consumption and location. They all preferred to avoid exposing their exact place of stay to all their online contacts, but five of them would not mind revealing the area or city they live in. All students were positive in sharing their personal data with online friends they trusted, since this would happen for a good purpose. Only one student mentioned laughing "*sometimes those you trust can harm you most*".

Citizens were less reluctant about privacy, since "*the government and many companies know already a lot about us*". Six of them agreed on sharing their personal consumption

No.	Question	Response
1.	Do you believe that Social Electricity respects your privacy?	Yes (77%), No (23%)
2.	If you think that Social Electricity does not respect your privacy, would you be satisfied if you shared your consumption only with people you trust?	Yes (60%), No (40%)
3.	If you think that Social Electricity does not respect your privacy, would you agree to share only some indicators of your personal consumption (e.g. daily/weekly peak or average consumption) for comparisons with your online friends?	Yes (47%), No (53%)
4.	Do you agree using your personal consumption for comparisons with your online friends?	Yes (85%), No (15%)
5.	Would you prefer comparisons involving your personal consumption or the average consumption of the street where you live?	Personal (41%), Street Average (59%)
6.	Are you worried about the possibility your personal consumption data to be revealed to third parties?	Yes (42%), No (58%)
7.	How significantly is your privacy affected by displaying the exact location where you live on the map?	2.98
8.	How significantly is your privacy affected by displaying the street where you live on the map?	2.42
9.	How significantly is your privacy affected by displaying your personal consumption data?	3.56
10.	How significantly is your privacy affected by displaying your historical personal consumption data?	2.55
11.	How significantly is your privacy affected by displaying the consumption data of your street?	2.33
12.	If you had the option to categorize your online contacts in different groups (e.g. relatives, family members, close friends), with whom would you be willing to share your neighborhood's consumption?	See Figure 1 (top-left)
13.	If you had the option to categorize your online contacts in different groups (e.g. relatives, family members, close friends), with whom would you be willing to share your home's total consumption?	See Figure 1 (top-right)
14.	If you had the option to categorize your online contacts in different groups (e.g. relatives, family members, close friends), with whom would you be willing to share the consumption of your electrical appliances?	See Figure 1 (bottom)

TABLE III. MAIN QUESTIONS OF THE ONLINE QUESTIONNAIRE IN THE CYPRUS CASE STUDY.

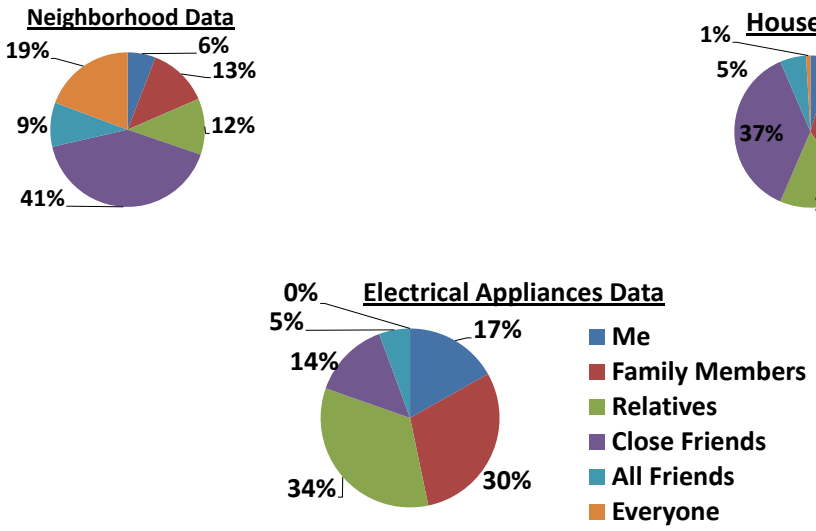

Fig. 1. Privacy concerns of users with regard to whom to share their consumption data in neighborhood level (top-left), house level (top-right) and detailed consumption of their appliances (bottom) in the Cyprus case study.

with their online contacts, and one declared that "*it is our duty to share our consumption, because our habits affect the environment and the society*". This is definitely an interesting point of view. The one who did not agree was content by sharing his personal information only with people he trusted. Regarding sharing of location, five agreed they wouldn't mind sharing their exact place of stay, since "*this is a common secret to everyone*". This can be explained perhaps since Cyprus is a small country with less than a million population, so it is easy to learn personal information about any citizen. The other two citizens who disagreed were also positive with the option of sharing only with people they trusted.

Sharing only some indicators of personal consumption did not sound appealing to both groups, as "*comparisons with my friends would not make really sense*". The only meaningful indicator agreed by students was that of energy savings. Citizens had a similar opinion, adding also average daily/monthly personal consumption as another good indicator. Both students and citizens agreed that the use of consumption indicators would mask their private data and enhance their privacy.

Then, we asked participants about their specific concerns of sharing their personal consumption with all their contacts or with everyone. Two students were afraid that exposing their personal consumption could encourage thieves "*to attempt to steal when the owner is not there*", by observing the absence patterns of the home residents. Citizens were not afraid that their consumption patterns could reveal their lifestyles and one claimed that "*common benefits overcome the risks*". Another

citizen noted that "*banks constitute more serious privacy risks as they know much about our personal lives*". Only one student was worried about criminal activities, similar to the two students.

Finally, we instructed our groups to elaborate the idea of sharing their personal consumption with trustworthy online contacts. Assigning contacts to categories was accepted as an effective option by both students and citizens, however, two students and one citizen believed that this might not be enough, since sometimes "*people you trust span across multiple categories*". For these three participants, one-by-one selection of contacts they trusted sounded more practical. All participants did not mind sharing their street consumption with their online friends.

B. Analysis of the Singapore Case Study

The analysis for the Singapore study involved the final reports of the students, at the end of the semester exercise, in which they were asked to declare their feedback on whether their privacy was respected through the application, or more measures are needed. From the 175 students in the study, 147 of them filled the final report.

Regarding the general question whether the application respected their privacy, 118 students (80%) believed the application fully respected their privacy, while from the rest 29 users (20%), 12% believed they exposed some place of stay information (even though they could hide their exact address), 4% that users could figure out their real names and 4% that they exposed their personal consumption.

An interesting question was whether they were willing to sacrifice their anonymity by using their real name, considering that this could put some social pressure on them to reduce their consumption, 52 students (35%) did not agree with this, preferring to maintain the possibility of staying anonymous. From the rest 95 students (65%), the following preferences were expressed:

- Share with Facebook friends only (8 students, 5%).
- Share with students from the course only (29 students, 20%).
- Share with students from my tutorial group only[4] (13 students, 9%).
- Share with particular contacts I can choose from (26 students, 17%).
- Share with everyone (19 students, 10%).

It is very interesting to notice that only 10% of the students wished to allow revealing their identity to everyone.

VI. Discussion

Apparently, in both case studies in Cyprus and Singapore, as indicated by online questionnaires, focus groups and students' final reports, a considerable percentage of users demand for more control over the sharing of their personal figures, whether this is their consumption or place of stay.

[4]Students were also divided in 4 tutorial groups per course, each having 12-15 students.

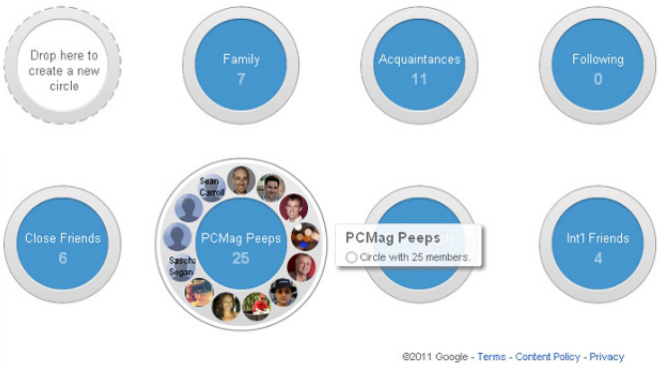

Fig. 2. Google+ approach for privacy using user circles.

The study in Cyprus revealed more information about privacy than the Singaporean one. However, in both it was apparent that some mechanism for protecting user's identity and location, and personal consumption information needs to be developed. Besides these two studies, our experiences after three years of Social Electricity operating around Cyprus and Europe, is that many citizens, both in Cyprus and around Europe, are reluctant to participate at all, being worried about sharing their personal data with their online friends and the user community in general.

In order to offer to users more control over this sharing of personal information, based on the feedback received through these case studies, we have enhanced the application with some privacy-related features [11], supporting the following services:

1) Complete control of the sharing of address or even general location.
2) Complete control of the sharing of any consumption information.
3) Complete control over whether to allow interaction with other groups of users.
4) Confidential one-to-one comparisons with users who have allowed such comparisons to take place.

For ensuring more complete privacy, we suggest a solution adopted by Google+[5], according to which users may categorize their friends in *privacy circles*. An example from Google+ is shown in Figure 2. Then, users can associate varying sensitivity levels with each of their circles, and share different electricity data with each of them (e.g. neighborhood data with all friends, home data with close friends and relatives, electrical appliances with family members).

From our case studies, it seems that people find this approach satisfactory for covering their privacy needs. Similar approaches have been suggested also in [15] and [16], with promising feedback from the users involved. As some participants of our user studies preferred a one-by-one selection of trustworthy online contacts, this can be satisfied by the concept of privacy circles, by means of maintaining only one circle,

[5]https://plus.google.com/up/connect

placing contacts they trusted inside this circle.

VII. Conclusions

The purpose of this paper is to study the privacy concerns of users of eco-feedback online social applications. To examine these concerns, we present the findings from two case studies performed in Cyprus and Singapore, by participants using Social Electricity, an online energy management tool offering social eco-feedback services in a collaborative environment.

A subjective evaluation, by means of online questionnaires and focus groups at the Cyprus case, and through final reports in a semester exercise at the Singapore case, showed that privacy issues are very important to a large percentage of users. The evaluation revealed the specific privacy concerns that users have in such large-scale persuasive environments. The participants stated clearly the requirement of sharing personal energy consumption data through a privacy policy that satisfies the ability of revealing different levels of energy consumption data (e.g. monthly/daily street or home consumption, consumption of individual appliances) to user-defined categories (privacy circles) inside social networking applications. Users prefer to share private and sensitive information only with the online contacts they trust.

Our future actions involve developing the concept of privacy circles on Social Electricity, examining its effectiveness in satisfying users privacy concerns, aiming to see whether this would encourage them to become less reluctant in participating to this application or relevant social online eco-feedback applications.

Overall, this paper demonstrates the need for further research in the area of privacy in online applications, towards better understanding the needs and concerns of people in terms of using online eco-feedback social applications.

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