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State and trends in mobile observation applications

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Abstract: The stellar growth of the smartphones and nearly gapless mobile network coverage in urban and suburban areas has widely extended the potential of the citizens' observatories. The possibility to easily record observations made by mobile citizens, and to automatically enrich this information using the built-in and external sensors sounds like a dream come true of the scientists and decision makers alike. However, in 2013 only a tiny portion of the potential users really participated in the citizen observation programs and the usability of the received information is often below expectations. The learning curve is often too high, sensor quality too low, the societal importance and the added value for the users not easily understood by the end users. Some of these obstacles can be overcome by improving the interaction with the users through crowdtasking and microlearning, others by re-assessing the application design and expectations.
In this paper, we shall present the best practice examples of the mobile observation usage in applications currently available on the market. We shall discuss the scope, potentials, limitations, obstacles, and ethical issues of these applications, compare them with the apps developed by the research community and reason on the best practices and possibilities to further improve the mobile observation apps in the future..

Keywords: crowdsourcing, crowdtasking, mobile observations, participatory sensing

1. Introduction

The seemingly unstoppable rise of smartphones as the ubiquitous communication and computational platform provides an opportunity for the development of nearly costless (at least for the organizer) mobile observation networks. Unsurprisingly, a number of re-searchers set to exploit this opportunity (Lane et al., 2010, 2012). Some of the resulting applications managed a transition from "experiment" to "deployment" and a few apps pertinent to environmental observations (Allen et al., 2012) and crisis management (Zook et al., 2010) have even made it all the way to headlines in web blogs and daily press.

Many of the apps developed by researchers are designed to test certain concepts or technology rather than growing into self-sustaining software with a large user base. In spite of this, we assume that the apps with a massive user base can teach us some lessons which will be applicable even to applications which are designed as limited-scale short-term experiments. In this paper, we shall therefore attempt to find parallels between some of the applications which are developed by the scientists present on this conference on the one side, and some of the most popular android applications in existence today on the other. Unless explicitly stated otherwise, the assessment methodology and criteria are based on the ideas introduced in (Havlik et al., 2013).

The paper starts by a guided tour through several classes of the popular applications which appeal to millions of users (section 2). The apps we are going to analyse are presented in the section 3, followed by a discussion of the similarities, gaps and opportunities (section 4). Finally, the conclusions and recommendations for the future developments are shown in the section 5.

2. Popular applications ("the champions")

A look at the Google play reveals several classes of applications which are extremely popular and to a certain extent relevant to this paper such as "social networking", "health and fitness", "travel", "shopping", "weather" or "transport". A closer look at the apps shows that the successful ones often span several categories, with maps and various social networking features appearing across the board. Other common traits include: use of third-party login services (e.g. Facebook, Google); powerful search, sorting and filtering capabilities; low (often zero) price, ease of use, and low level of demand on users. In fact, almost every successful application we analysed is primarily designed to aid users explore the information already available in the system. Contributing of the own observations or assessing the already available information is optional and encouraged by "soft" measures, but never seen as the primary functionality or demanded from the users.

The three application classes actually discussed in this section were chosen based on the authors own usage patterns and the influence these apps had on the own design decisions while developing the ENVIROFI apps (see section 3.1).

2.1 Geroreferenced images

A completely unscientific survey among our colleagues has led the authors of this paper to believe that a great majority of the human kind enjoys taking enormous numbers of photographs and sharing them with friends and the family. Some of us are even inclined to use online services such as Google+ (https://plus.google.com) or Flickr (https://www.flickr.com/) for automated backup of every photo we make, but organizing and annotating these photo collections is often neglected.

Only a tiny fraction of the photos is ever made public and an ever smaller fraction of these is geo-referenced. Nevertheless, the number of publicly available geo-referenced photographs at can be astonishingly high, even at the most unexpected places (see figure 1).

Figure 1. Panoramio coverage of central square of Vienna, Austria (left) and of the Franz Josef Land, Russia (right)

The success formula of "Panoramio" (http://www.panoramio.com/) and similar applications is simple:

1. Let users share the geo-referenced photographs.
2. Provide several easy to use interfaces for accessing the photographs. Typically the applications provide map view, time view and different types of automatically or manually generated thematic views.
3. Assure the "best" photos are shown first, This is usually based on authors reputation (proxy: number of subscribers) apparent interest for the photo (proxy: number of views), and relevance (proxy: search through tags attached to the photo)

The meta-information on photographs (name, description, topics/tags, comments), this information is optional and likely to be attached only to photos the authors or visitors really appreciate. Consequently, the users can automatically upload huge photo collections with virtually no effort. On the other hand, built-in social networking and the sorting algorithms assure that a tiny fraction of the authors and photographs which are, for whatever reason, considered "interesting" by the users also gets a major share of the attention. Resulting self-reinforcing loop assures that such photos are eventually enriched with abundant, appropriate and accurate meta-information and the applications are able to provide excellent impressions of virtually any place on earth.

These services are provided free of charge for a great majority of the users, and feature very few advertisements. The return of investments for the application owners can thus only be indirect, e.g. through customer binding and profiling for the usage in other applications. The fact that the user profiles are the real product from the point of the view of the application owners appears to be societally acceptable for a huge number of users. The risk of exposure through own public photographs can be considered reasonable for the adults, while the risk posed by inappropriate third-party photos can be mitigated through existing legal framework.

2.2 Sport and health applications

The Sport Tracker (http://www.sports-tracker.com) stands for another extremely popular class of the mobile observation applications. It uses the sensors provided by the smartphone (mainly GPS) to track users' workouts. Combined with an optional heart rate monitor, the application can provide additional information on the users' fitness level and help the users' to optimize own trainings. Sport Tracker greatly simplifies analysis and exploring of the own accomplishments (figure 2), exports of tracks in GPS exchange format, as well as sharing of the tracks with the friends, family and even with the complete strangers on sport tracker web site, through Facebook and Twitter.

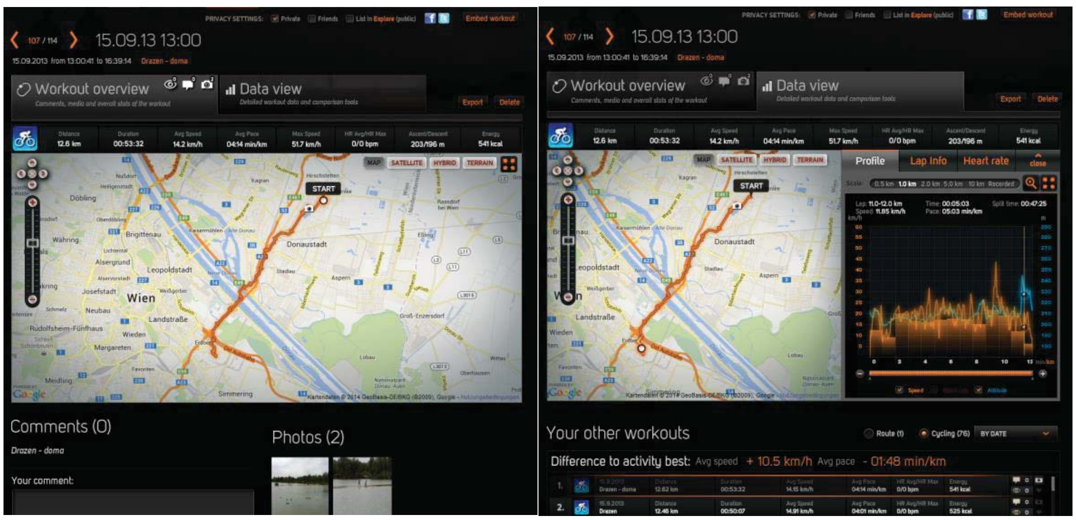

Figure 2. Sport tracker web interface. Workout overview (left), data view (right)

The use of the web service and the smartphone app(s) are free of charge. Although the "privacy policy" explicitly mentions the possibility of using the users' data for profiling and targeted advertising, the sports-tracker apparently opted for a freemium business model (Freemium business model (http://en.wikipedia.org/wiki/Freemium). The app and web site do not present the users with any third party advertisements and the sales of heart rate monitors appear to be the only source of income. While this is certainly good news for Sport Trackers users, this class of applications has potentially huge ethical implications: the individual health status, which can be easily deducted from the data kept on the backend server, is sensitive personal information which could be potentially misused.

2.3. Traffic and mapping applications

Last class of the applications presented in this paper is by far the most important one in terms of the user base and frequency of use. Although the OpenStreetMap (http://www.openstreetmap.org) clearly demonstrates the value of user-contributed map elements, most mainstream providers only marginally relay on users feedback for enriching the information base, e.g. by contributing additional photographs or rating of the hotels and restaurants.

An exceptionally successful exception to this rule is the emerging class of the community-based traffic and navigation apps. These apps use the information provided by app users to optimize the routes and warn the users of hazards and opportunities ahead. One of the best known such apps is Waze (https://www.waze.com), which has been recently purchased by Google. Waze provides following functions:

- Optimized routing which takes into account the real-time information on the traffic flow based on automated tracking of the Waze users (opportunistic sensing).
- Community-enabled reporting and sharing of information relevant for the drivers, including the accident reports, hazards related to road condition, fuel prices as well as the positions of the police controls (participative sensing).
- Community-edited maps
- Sharing of position and intended destinations with friends and family

The most striking feature of the observations gathered by Waze is their volatility: in order to be of any use, the information on the accident reports, hazards or fuel prices must be updated very frequently.

The most interesting lesson we can learn from Waze and similar applications such as Trapster (https://www.trapster.com/) is the following: it is indeed possible to build an astonishingly accurate "here and now" understanding for large part of the world based entirely on the observation which are actively provided by the users (participative sensing). In order to reach this goal, Waze relies on following pillars:

- High perceived value of the information for the users
- Simple and easy to use reporting interface
- Targeted requests for observations (crowdtasking)
- Incentives for participation in form of "points"

Offering of the map and rooting functionality free of charge makes great business sense as a part of a larger Google ecosystem where the knowledge of the users' habits and whereabouts is the major company asset and the income is primarily generated indirectly, through targeted advertising on millions of web sites completely unrelated to this service.

3. Research apps analysed in this paper

3.1. ENVIROFI apps

ENVIROFI European research project explored the synergies between the existing technology and application needs of the Environmental Information Space and the emerging functionalities of the Future Internet (Havlik et al., 2011). The main focus was to understand and explore new concepts and technologies rather than building perfectly working applications. Although the ENVIROFI development stopped at the level of "proof of concept", the concepts and technology are currently reused by AIT in the risk management domain, with the target of delivering a fully-fledged crowdsourcing/crowdtasking application for crisis and disaster management (Neubauer et al., 2013).

ENVIROFI "biodiversity" app implements a biodiversity (tree) occurrence reporting and data exploring system for both experts and the amateur biodiversity explorers (Schleidt et al., 2013), and the "personal environmental information system" (PEIS) app allows the users to correlate their personal well-being with the local weather and exposure information (Van der Schaaf et al., 2012). Both apps provide three main functions: (1) viewing of known information/observations, (2) reporting of additional information/observations such as new tree occurrences and users reactions to environment; and (3) alerting functionality which takes into account the users interests, time and position.

The key design decisions which shaped the two apps and the lessons learned are explained in (Havlik et al., 2013) and summarized hereafter:

1. Main value of the application for the user lies in fusion of the data from all available sources and presentation of the results in a form which is easily understood and used. As a result, the "view existing knowledge" function will be invoked far more frequently than "report observation" (see figure 3)
2. Microlearning and crowdtasking can both improve the observation quality and boost the user motivation (Voigt et al., 2013).
3. No data is a-priory valid. The validity and accuracy of the data can be assessed with several independent processes (heuristic, peer review), and the final interpretation is application-dependent. This "no single truth" principle means that two applications may use the same data and still arrive at different conclusions.

4. Touchscreen is not the only user interface on a smartphone. Some of the user input can be more conveniently obtained using the built-in sensors (e.g. accelerometer) or through "offline" user interfaces such as NFC tags and QR codes.
5. In order to prevent misuse, the application should be designed in a way which minimizes the amount of the observations automatically reporting of the observations to the server (in particular: no automatic tracking). In addition, the sensitive data should be processed on the phone and not on the backend server whenever possible.

This favours participatory sensing over opportunistic and automatic sensing, but the limitations can be mitigated for instance by: (1) automatically recording and process data on the phone and uploading the results after explicit users consent or (2) allowing the users to explicitly indicate the time- and space- boundaries for automated sensing .

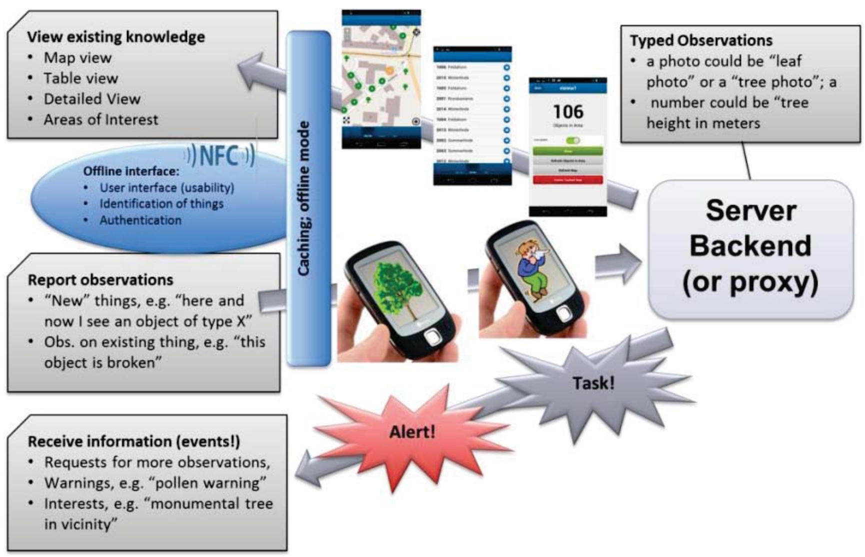

Figure 3. Main functions of the ENVIROFI apps (from Havlik et al., 2013).

3.2. ZmapujTo

ZmapujTo (mapThat) is a fully fledged web platform which improves the communication between the citizens and the municipality they live in. The application is seen as a way to optimize the use of (paid) human resources and maximize impacts by the municipalities and therefore likely to remain sustainable in foreseeable future.

ZmapujTo was developed by Institute of Biostatistics and Analyses at the Faculty of Medicine and the Faculty of Science of the Masaryk University, Brno Czech Republic, with two primary goals: (1) enhance the public awareness of the threats posed by illegal dump sites; and (2) allow citizens to map new dump sites and municipalities to inform the citizens how they are resolving each of the reported issues (Kubásek, Hřebíček, 2013). The application allows citizens to report the issues through several channels including web and smartphone apps, e-mail and MMS and enhances the reports with user-provided photos and information from other sources such as cadastral maps. As a result, the municipalities can easily find the ground-owners of the reported sites and start mitigation activities.
The latest version of the application adds two significant improvements (Kubásek, Hřebíček, 2014):

- ad-hoc organization of "voluntary events"; and
- observations of other civic issues, e.g. "overfilled garbage cans".

3.3. PocketLAI

PocketLAI© (patent pending) is a smartphone app which allows the users to estimate the degree of the leaf coverage using the sensors available in standard smartphones (Francone et al., 2014). More accurately, the app guides the user through a process of providing a standardized set of observations including not only a photography taken at predefined inclination, but also the additional information on conditions under which the photography was taken and calculates the leaf area index (LAI). The LAI is defined as the one-sided green leaf area per unit ground surface area (LAI = leaf area / ground area, m2 / m2) in broadleaf canopies and used to predict photosynthetic primary production, evapotranspiration and as a reference tool for crop growth.

The app thus promises to provide valuable information on the crop growth and expected crop yield at a fraction of price of the traditional LAI measurements. Some interesting characteristics of the app are discussed in (Confalonier et al., 2014):

- The built-in illustrated “quick manual” and the workflow imposed by the app user interface makes it almost impossible to accidentally record misleading observations.
- The great variety of the sensors used in smartphones makes it nearly impossible to use the app without device specific calibration
- Judging from the data shown in figures 2 and 3 of Confalonier et al., 2014, the measurement accuracy (with or without the calibration) is highly dependent on the quality of camera built in the smartphone.

3.4. e-mobiliTI living lab app

E-mobiliTI project (Cellina et al., 2013) aimed at elaborating policy guidelines, incentives, procedures and strategies for a transition in the mobility sector at the urban level. A custom mobile application was used to: (1) automatically track the users’ daily travels; and (2) receive additional information on the trips taken from users. The GPS tracks were automatically transferred to backend server and processed to guess the transportation mean, travel segments and round trips. ´Scheduled daily feedback sessions were, among other, used to control and correct the results of the automated processing.

The application thus combines automatic information gathering with no user intervention with the daily reports which require significant and repetitive effort from the user. Moreover, the daily feedback session had no obvious and immediate value for the users. Even though the application was used only by a small group of dedicated volunteers, the (Rizolli et al., 2014) clearly indicate that motivating the users to provide such daily reports in due quality is a very difficult task. Other important issues emphasized in the paper included:

- battery drain by data tracking app;
- gaps in GPS connection; and
- the inability of the backend system to accurately indicate segments and means of transportation;

4. Application comparison

Although we all cook with water, the results do not always taste the same. In order to understand why, it is important to understand the process and ingredients, as well as the intent of the cook. Following this analogy, we shall look for some obvious similarities and differences, between the applications introduced in sections 2 and 3: The result of this analysis is presented in tables 1 and 2 below. Please note that the tables are filled with future exploitation potential in mind and may not (yet) be implemented for the four research apps. Important but not shown in the table is that almost all apps target very large groups of users (“almost everyone”). The most notable exception is the PocketLAI which offers a potentially large benefit to a relatively small group of users.

	Panoramio	Sports-tracker	Waze	ENVIROFI	ZmapujTO	PocketLAI	e-mobiliTI
Participative sensing	Geo-referenced photos, comments, tagging	own tracks (sport activities); hearth rate (opt.)	Hazards reports, map improvements	Tree occur. and additional observations; reactions to environment	Positions of illegal dump sites	Georeferenced photos, inclination, weather conditions	comments and explanations for travels
Opport. sensing	photos (optional)	-	Current speed & position	-	-	-	daily trips (tracks, segments)
Backend processing	Ranking	-	Routing	Plausibility, leaf detection	Land owners		Segments, transport mean
Frontend processing	-	Speed, calories	-	Health/env. correlation (concept)	-	Leaf area index	-
sensors used	Camera, GPS	GPS optional: camera, heart rate	GPS	GPS, camera, ambient pressure	GPS optional: camera	GPS, camera, inclinometer	GPS, accelerometer
Public/private ratio	Low for most users;	Low for most users	Mostly public	high for biodiv, low for PEIS	high	No sharing?	No sharing?

Table 1. Sensing and processing features of the analysed apps. Note: Question marks indicate uncertainty due to lack of data (placeholders or “educated guesses”).

Analysis of the data presented in Table 1 shows:

- In the small sample of apps we analysed, the participative sensing outweighs opportunistic sensing, and the processing of the data on the smartphone (frontend) is quite common. Moreover, all apps rely on users for at least parts of the observations (e.g. “activity type” in Sport Tracker, “reason for a trip” in e-mobiliTI).
- GPS and camera are by far the most important hardware sensors, but ENVIROFI and Sports Tracker examples remind us other that built in and even external sensors exist and will be used if and where necessary. In addition, the PocketLAI example reminds us that the way we use the sensor readings can make a huge difference.
- The ratio of public to private observations differs widely between applications.

The second table (table 2) below concentrates on the features which are relevant to sustainability of the apps such as user motivation and the business models and shows that:

- Financial gain or savings are important motivations for Waze and the PocketLAI users, as well as for the municipalities which are financing for example the ZmapujTo hosting and development. However, the Waze is so dependent on its users that it cannot demand any fees for the use of its service.
- Enhanced situation awareness, as a base for individual and/or collective decisions is a major benefit in Waze, ENVIROFI apps, ZmapujTO and PocketLAI and and also identified as the additional benefit in the case of Sport Tracker and e-mobiliTI.
- “Soft” means of persuasion through peer feedback are used in all applications: “standing” among peers is an important motivation in Panoramio, Sports Tracker, Waze and EnviroFI, and to a somewhat lesser extent in ZmapujTo. Waze and ENVIROFI resort to crowdtasking, and Waze also uses virtual currency (“points”) as a way to express gratitude and motivate observation contributors.

- All apps provide some sort of help functionality. However, only ENVIROFI apps have ventured into the area of "microlearning", through popups explaining the application functions when first used and the feedback on own observations being used as a mean to teach users to recognise the tree species.

	Panoramio	Sports-tracker	Waze	ENVIROFI	ZmapujTO	PocketLAI	e-mobiliTI
User benefit	Backup & manage and present photos;	progress and achievements; (own, pears)	Lower cost and duration of trips	Tree identification, own reactions to environment	Higher quality of life;	Track crop growth, estimate yields	Improved awareness of own habits
Owner & secundary user benefits	Bind & profile users;	Sell sensors	Bind & profile users;	less work, profile users, map trees,	Less work; higher visibility of activities	Sell app; overview of crop growth	Understand travel patterns
Common and societal benefits	Explore geo-referenced photos	Encourage healthy lifestyle	Energy savings	Knowledge,	optimized use of public resources	Lower food prices?	encourage eco-mobility
Motivation aid	Peer reactions	Peer reactions	Points, tasks	tasks, personalized alerts	Municipality and peer reactions	-	by project team
Help	Online manuals	FAQ, community support	Forum, wiki, FAQ	Context-sensitive, feedback on observations	?	Built-in "quick manual"	Live support
Ethical concerns	Medium (interests)	High (health)	Medium (tracking)	High (health, endangered species)	Low	Low	Medium (tracking)
Other concerns	offensive photos, mobbing	-	-	Offline mode; minimal intrusion by design.	-	Sensor accuracy	Sensor accuracy, battery
Business model	user profiles	Freemium;	user profiles	Secondary users (biodiv), freemium or user profiles (PEIS)	Secondary users (municipalities)	Software licenses	Project

Table 2.Sustainability-related app features. Note: Question marks indicate uncertainty due to lack of data (placeholders or "educated guesses").

5. Conclusions and recommendations

In spite of the small sample we took, the analysis performed reveals several interesting patterns. For one thing, the "user's motivation" is the decisive factor deciding on the fate of the app. Assuming that all other factors are the same, the most successful apps are likely to be the ones which are visually attractive, easy or even fun to use, demand a minimum of the users' attention (minimal intrusion) and do the best job at additionally motivating the users.

As a consequence, all apps analysed in this paper feature simple and easy to use GUI designs, and try to avoid anything which could make the users feel uncomfortable or annoyed: all the apps are free of charge; none relies on in-app advertising, and all except the PocketLAI and e-mobiliTI go out of the way to provide valuable service even for the users that never contribute any observations. In addition, the sensitivity of the data gathered by the app apparently influenced the adopted business model of the Sport Tracker as well as the architecture of the ENVIROFI apps. Finally, the apps which require significant efforts from the users (Waze, ENVIROFI apps, ZmapujTo) also feature additional motivation-boosting functions.

Of course, all things are not equal, and the inherent user motivation is highly dependent on the perceived value of the application for the users. While Waze and PocketLAI may be to some extent motivated by the wish to save money, key motivational factors include “fun”, “recognition”, “curiosity” and the wish to make the world a little bit better place. Other simple and inexpensive motivation-rising measures include the “feedback from peers” which is inherent to social networking, “virtual payment”/recognition (Waze) and crowdtasking (Waze, ENVIROFI).

However, our experience in ENVIROFI shows that the altruism can easily turn into a de-motivation for a research project: while our test users were in principle ready to contribute far more observations on biodiversity, they did not like the idea of spending their efforts on a test data which will be dumped after the project end. Looking back, we feel that even such a simple measure like automatic uploading of tree photos to users’ of google+ or flickr and attaching their additional observations as plain text would have been a great motivation boost for the respective test users.

In research context, it is quite common that applications (e.g. e-MobiliTI) are financed by a project (chain) and discarded afterwards. Sustaining the app after the project end through selling of software licenses is a niche business model and may be suitable for the apps which provide very valuable information to a relatively small number of users (e.g. PocketLAI). A majority of the apps we analysed is however provided free of charge to the end users. In some cases (e.g. ZmapujTo), the financing is provided by organisations interested in the observations, or in the possibility to communicate with the end-users. Another prominent reason for financing such free services is the wish to obtain users profiles and use this knowledge for targeted marketing activities. The examples of Google and Facebook show that this business model works extremely well for apps with moderate benefits and broad user base. However, the freemium business model, where basic functionality is provided free of charge and the users pay for the optional extras may be more appropriate for smaller companies, and for the apps relying on sensitive user data (e.g. Sport Tracker).

Finally, we noticed that two important recommendations from ENVIROFI, aren’t found in the other apps we analysed: (1) microlearning as a way to improve the users motivation and quality of informations and (2) frontend processing of the data, as a way to minimize the possibility of the massive data misuse by application owners and data thieves.

6. Acknowledgments

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