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Innovative Social Location-Aware Services for Mobile Phones

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INTRODUCTION

Social media such as Facebook, YouTube, Twitter, and Social Lab (Reips and Garaizar, Chapter 29, this Handbook) have empowered users by allowing them to *produce* and consume information (Bruns, 2008). This trend has then moved to mobile social services, which offer a natural way of supporting social interaction through mobile devices anywhere at any time. At the same time, mobile location-based services (LBS) like Foursquare have appeared that enable users to describe, rate, and interact with urban spaces by location-aware services.

The Mobile User Generated Geo Services (MUGGES) project (Klein et al., 2014), funded by the European Commission's 7th Framework Programme, went a step further from mobile LBS by providing a platform that allows users to not only create simple content but evolve them to micro services that embed complex business logic like – for example, map navigation, blogs, and photo albums. In addition, users in the MUGGES ecosystem provide their contents directly from the mobile device, that is the mobile device evolves to be a server. Thus, mobile users turn into location-aware service super-prosumers (Klein et al., 2014), that is producers, providers, and consumers of services and associated content from their mobile devices. In this chapter, we report on a living lab environment that was developed as part of the MUGGES project to extract and visualize environmentally embedded social behaviors from a continuous stream of usage data.

After this introduction, the chapter discusses related research to provide the needed background and then focuses on the MUGGES system itself, providing an explanation of the key topics behind MUGGES: the super-prosumer role of users, the service creation concept, the peer-to-peer architecture, and the location management. Then we describe the living lab concept (Bergvall-Kåreborn et al., 2009) employed to evaluate MUGGES in field studies conducted in Finland and Spain and provide a description of these studies. Next we present the results and discuss the technology, usage, and psychological experience before the final section summarizes and concludes the chapter.

RELATED RESEARCH

The MUGGES platform represents a mobile peer-to-peer system leading to fairly short-term and highly dynamic user communities. Evaluating such a complex ecosystem represents a major challenge. We conducted a literature survey to compare different approaches focusing on *lab* and *field* based studies and assessed their benefits and limitations.

Lab-based evaluation frameworks log information in a controlled environment using specific devices and specific users. The main advantage of lab-based frameworks is the highly controlled environment and the inexpensive and simple data collection. However, the context, which is the most influential factor in the mobile services field, is often not considered in lab-based research and can hardly be simulated. For instance, people usually use cellphones less frequently or for shorter periods of time in dangerous situations, stressful environments or simply during rain. Simulation tools produce highly inaccurate results because they cannot adequately account for real-world contexts. Furthermore, lab experimenters and designers of the usability tasks performed by the users often evoke situations that are unrealistic. Technologies might interact with participant personality and thus bias the sample (Buchanan and Reips, 2001; Götz et al., 2017). The users may also add biased results during the execution of the experiments (Reips, 2006) because they suffer from problems such as test anxiety (Cassady and Johnson, 2002): during the task performance a highly test anxious person divides the attention between self-relevant and task-relevant variables; due to the self-focused attention, the user of the mobile service may not show real behavior. Further, in many task situations such as cellphone calls, it would be subjectively annoying for many users to be in a room being observed by researchers.

Alternatively, field-based evaluation frameworks (see Table 24.1) capture information in real environments. They commonly use added cameras and human observers to capture information from user device interactions. For example, the *User testing platform*[1] not only uses methods like a think-aloud verbal protocol but also records feedback on how users perceive the study object by filming the face or recording comments with a webcam. Finally, it reproduces the user interaction at a given time through screen captures that can in a subsequent step be annotated with additional explanatory data like the current usage context. Another tool related to user testing is the *Morae Observer*[2] tool. It captures all the above mentioned interaction data, indexes it to one master timeline for instant retrieval and analysis, and then generates graphs of usability metrics. Another group of tools such as *ContextPhone* (Raento et al., 2005) and *RECON* (Jensen, 2009) are focused on capturing the context. They capture the surrounding environment through mobile sensors. This capturing technique retrieves a lot of real data without influencing the interaction, but users are not asked to provide feedback. In order to add user feedback other tools like *MyExperience* (Froehlich et al., 2007) and *SocioXensor* (Mulder et al., 2005) use techniques like self-reports, surveys, and interviews in combination with capturing the context.

To sum up, to acquire valid interaction data about mobile services, it is essential to capture objective behavioral information to solve questions like 'when', 'where', 'how long', etc. users are really interacting with a service. These questions can hardly be determined in a lab-based framework. Field-based evaluation frameworks

Table 24.1 Comparison of analysis tools

Tool	*Capture technique*	*Reported data*	*Graph visualization*
User testing	Screen, webcam and microphone	Interaction, user information and user feedback	Reproduce the screen, interaction
Morae Observer	Screen, webcam, microphone and observer	Interaction, user information and user feedback	Reproduce the interaction and calculate graphs
ContextPhone	Mobile sensing and interaction event logging	Interaction, device status and environment	Mobility pattern detection
RECON	Interaction event logging and mobile sensing	Interaction, device status and environment	Trace data, analysis engine
MyExperience	Wearable hardware sensing, mobile sensing, audio recording and user surveys	Interaction, device status, user information, user feedback, and environment	Performance analysis, SMS usage and mobility analysis
SocioXensor	Interaction event logging, survey interview	Interaction, user, device status and environment	SQL database

can provide deeper and more objective information, but certain agents such as cameras and invasive evaluation methods (e.g. think-aloud verbal protocols) are counterproductive and need to be removed from the fieldwork methodology for the current purpose. In order to do so, the best way to capture interaction data is by registering information through a mobile device using an unobtrusive capture tool (see also Reyes-Portillo et al., Chapter 29, this Handbook). This tool should log the context via the built-in mobile sensors and log the key interaction events.

THE MUGGES SYSTEM

The MUGGES system was implemented as a hybrid peer-to-peer platform that is composed of a micro service communication network and core network that forms the infrastructure backbone managed through a telecom provider.

Micro services and related content are stored on the phones of the end-users. They use the micro service communication network to exchange data directly from phone-to-phone, giving their users full control over their content at any time. Note that this approach is fundamentally different from commercial social media where the content is hosted by providers such as Facebook and very often cannot easily be withdrawn.

Micro services automate the information exchange between people by providing shared functions such as blogs, coordinated maps, and photo albums through the infrastructure backbone of the MUGGES platform. Especially while traveling, people's time for interpersonal communication is limited due to the need to monitor important environment changes. Micro services that automate this communication play an important role to ease coordination and enable ongoing socialization even during traveling.

A telecom provider hosts the micro service repository, additional administration functions such as user management and accounting, and infrastructure services like location management. The hybrid peer-to-peer architecture was chosen by one telecom provider as part of the project consortium to enable a smooth integration with existing social media platforms.

Mugglets

Figure 24.1 shows screenshots from MUGGES. Within MUGGES micro services are called *mugglets*, which are small, independent, location-based social services hosted in the mobile terminal and provided from one mobile device to another mobile device. The advantage of mugglets is that users can correlate digital information with places. MUGGES provides predefined templates that can be customized to personal preferences. We distinguish basic and mashup templates, where the latter combines functionality from one or more basic templates. The following three mugglet templates have been designed within the MUGGES project to show their benefits:

- *muggesNote*: This mugglet template allows the publishing of a short message with a photo referring to a specific location. The physical location of the user is automatically obtained by the positioning service of the mobile phone during the creation process. Such a message can describe physical objects like a building or can be used to

Figure 24.1 MUGGES application interfaces – a) muggesNote, b) muggesNote photo view, c) muggesJournal, d) muggesTrail, e) muggesRace

refer to any comments related to activities usually performed at this location. Other users can then retrieve these messages at this location (see Figures 24.1a and b).

- *muggesJournal*: The main objective of this mugglet template is to maintain a journal attached to the current position of the user. This mugglet template represents a mashup, as it contains a set of semantically related muggesNotes – for example, 'my soccer tournaments', maintained by a single author and ordered by date. Each muggesNote has its own location (see Figure 24.1c), so a muggesJournal can combine notes from several locations.
- *muggesTrail*: This mugglet template is also a mashup that allows users to define routes with information about places along the routes by adding sequences of muggesNotes (a starting point, intermediate points, and a goal) arranged in a specific geographic order. This kind of mugglet template allows users to see the directions from their current location to the next point on the route, with the aim of guiding them to the end of the route without trouble (see Figure 24.1d). A typical scenario could be recommending tours to tourists in a given city. muggesRace is a slightly modified version of muggesTrail that uses spatio-temporal data to organize jogging competitions.

Service Creation, Provision, and Consumption

After installing the MUGGES platform users can create their own mugglets, or query for existing ones and install them on their cellphones.

Users create their own mugglets by downloading templates and modifying them. The mugglet creation for mashups is very similar but with the difference that previously created muggesNotes can be added to it. We made a big effort to generate an intuitive service creation process. A software installation wizard-like approach was adopted that uses templates to keep the overall duration for the creation of micro services for the user to an absolute minimum. This wizard guides the user in the template customization process by providing forms in a specific chronological order (see Figure 24.2). Templates basically consist of four parts:

1. Mugglet profile for service discovery: the profile contains the mugglet name, keywords, and describes minimum requirements for service installation.
2. Mugglet content objects: mugglet content can be any text description, user comment, or multimedia object like a photo. Metadata associated with content objects define the content appearance and access in the mugglet.
3. Execution logic such as chat functions, blog management, map navigation, and photo services. The execution logic retrieves and represents content on the user interface.
4. User interface representation that includes style sheets for chat, blogs, maps, and photo albums. Each mugglet has its own user interface and may contain several elements like buttons, text fields, maps, and image controls.

Once mugglets have been created from one of the three templates they can be published and are searchable via the query interface. For querying of existing mugglets, users may apply a keyword-, template-, or map-based search method to identify interesting mugglets. After downloading and installing the mugglet on their device users can execute the mugglet. Communication is then handled directly between the mugglet provider and

Figure 24.2 Mugglet Creation Wizard

the consumer. Always, mugglet providers keep complete control over their mugglets and can terminate them at any time.

User-Aware Location Technology

Mugglets are connected to the physical world through location references. These location references become a crucial filter to search and access mugglets (Kaasinen, 2003). Managing locations can be complicated due to different interpretations by humans. It is the responsibility of the MUGGES infrastructure to identify the user location by interpreting different location specifications. In contrast to machines, people use different mechanisms to represent location data. While computers use numerical representations, people use concepts and landmarks – for example, near the station, at the museum, in the market area. Hence, the MUGGES infrastructure has to correctly interpret expressions at a semantic level and execute them accordingly on the technical layer. The MUGGES location concept distinguishes between physical, symbolic, and semantic locations and has been described earlier in Klein et al. (2014), or see Becker and Dürr (2005) for a more general description:

- *Physical*: A point in a reference system (it might be accompanied by a geometric bounding shape). In geographic systems this is typically expressed through latitude, longitude, and altitude coordinates – for example, the city center of Bilbao, Spain, is located at latitude: 431525, longitude: –25524, altitude: 19m.
- *Symbolic*: A human-readable and understandable textual description of a location – for example, 'University of Konstanz, Germany' or 'the Netherlands'. See also Becker and Dürr (2005) for a more specific description.
- *Semantic*: A machine-understandable location expression upon which location-related inferences can be undertaken – for example, the University of Deusto lies in the city of Bilbao, which in turn is located in the Basque Country, in Spain, and so on.

Conventionally, only one of those facets is specified while searching for mugglets – for example, either the physical location or the symbolic description. It is the MUGGES infrastructure that translates, if possible, among the different instances of location specifications so as to fulfill the requested location-related tasks.

METHODOLOGY

The assessment of the MUGGES system is based on a living lab concept (Bergvall-Kåreborn et al., 2009). A living lab is an open innovation ecosystem where different technology providers and end-users collaborate in a realistic environment with the goal to achieve best product quality. The idea of living labs originated from the domain of ambient intelligence, where real life study situations play a key role for successful evaluations. The strength of such an approach lies in the close engagement between end-users and service providers. Survey and usage data are collected with the aim of continuously improving the technology.

Study Design

In order to learn more about the benefits of a mobile location-based service approach, we use surveys to gain information on users' perceptions regarding the MUGGES technology and log data analysis to compare these with real MUGGES usage (see Figure 24.3). Self-reporting of phone usage, a widely used method (Boase and Ling, 2013), most likely leads to under reporting as MUGGES automates social coordination in the background of the user. It can also not explain why people have not used MUGGES in specific situations due to missing context data. We believe that this combined approach is suitable to evaluate technology and the functioning of the system.

For the survey we created a simple questionnaire based on the Technical Acceptance Model (TAM) (Davis, 1989), the most widely applied model of users' acceptance and usage of technology (Venkatesh, 2000). According to Wikipedia (Technical Acceptance Model, 2016), the TAM model represents an extension of Ajzen and Fishbein's (1980) theory of reasoned action and considers the usefulness of a service and the ease of use as primary factors to influence technology adaption. Perceived usefulness describes to what level persons believe that using a given technology would enhance their task performance. Perceived ease of use, on the other hand, refers to the degree to which a person believes that using a technology would free them from effort in contrast to alternative approaches.

In the case of MUGGES, the usefulness is related to various sub-aspects like service creation, provision, discovery, and consumption. Perceived ease of use describes the degree to which a user expects that using this service is free of effort. Normally these include different aspects of interface

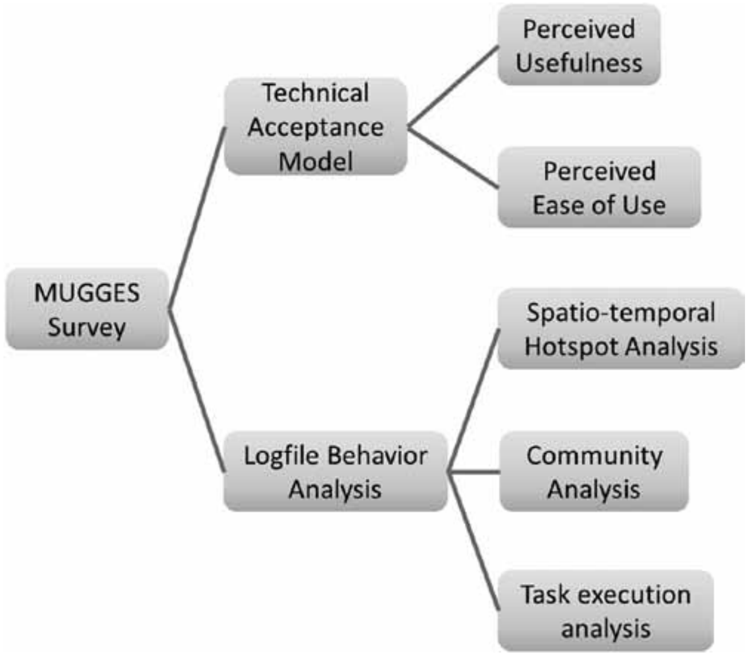

Figure 24.3 Study design overview

learning, memorization, and efficiency. Because the user interfaces in MUGGES follow heterogeneous approaches, the mugglet creation kit and mugglets are evaluated separately. For the log file analysis, we combined data from the data logger with general user and mugglet data managed by the MUGGES system. Thus, aspects of the user interface, events, and mugglet execution states stored on different servers can be correlated. Examples for log data are: service start and stop times, user interface (UI) events – for example, buttons pressed, screen transitions, any changes in settings and erroneous data entries, exceptions, and any unexpected system behavior (Reips and Stieger, 2004; also see Stieger and Reips, 2010). All events registered in the logs contain geo-coordinates and timestamps. This time and location data is used to identify characteristic spatiotemporal mugglet usage patterns of individual users. Timestamp information allows us to speculate about preferred usage times on an hourly or weekly basis. Grouping events from location data can reveal usage hotspots. The resulting spatial cluster structure can reveal if study participants prefer to use the system in a carefully planned or rather spontaneous manner. People who carefully plan their MUGGES tagging activities tend to describe places that they have visited multiple times before and know very well in advance, resulting typically in a very limited number of high quality muggesNotes. This is in strong contrast to a person that uses MUGGES rather spontaneously and seems to explore the environment. Such a person obviously creates more scattered muggesNotes and keeps most of them, even if they don't perceive them later as good choices.

Because MUGGES represents a social network, it is interesting to gain more information about the communities formed around specific mugglets. Interesting aspects are the average size and duration, but also the number of active users in such communities. Therefore, user and subscription data are aggregated for each mugglet in order to calculate the average community size, average provision duration, and provider–consumer ratio. Finally, a functional analysis is conducted. By analyzing entire user task chains from service creation and editing to the provision of mugglets, we can learn how people deal with time constraints or what workaround they find to compensate for problematic usage situations.

User Groups

When the evaluation studies were prepared, the MUGGES platform was still in an early development stage, so it was decided to ask technically experienced users for participation. The assumption hereby was that participants with a technical background would be more likely to cope with problems and could provide more adequate feedback. For the first study, eight participants were selected from a group of IT professionals in

Finland. Although we actively tried to recruit a mixed gender sample, we found no female volunteers in Finland. All Finnish participants were between the ages of 25 and 35 and were employed at the VTT research institute. In Spain, it was decided to select 17 computer science students from the University of Deusto, where the prototype had been developed. All students were between 20 and 26 years old and were mostly men (only two of them were female).

A pre-study questionnaire about their cellphones and past experience with mobile applications showed that both participant groups could be considered early adopters as defined by Rogers (2003). All participants were equipped with smartphones offering features for embedded WiFi networks, GPS,[3] camera, and music players (see Figure 24.4a). At the time of interviewing they used various mobile applications that utilized the built-in camera and GPS systems and frequently used web applications. Spanish participants spent more money on their cellphones than Finnish participants (see Figure 24.4b). This could be a hint that Spanish participants saw cellphones as a primary means to coordinate their life whereas Finnish participants mainly relied on their desktop PCs. However, due to variations between the two sample groups (e.g., age) it was impossible to determine if this was a national difference or an age difference or something else (e.g., climate). All participants lived in densely populated areas: in the center of a city or close to it (see Figure 24.5a). Most participants traveled around 11–50 km to get to their workplace or university (see Figure 24.5b). Such a travel distance with public transportation may take around 30 minutes. This time frame is certainly enough to check on individual mugglets or even maintain them. High average travel distances of the Spanish students resulted from some participants commuting every day between different cities – for example, between Vitoria-Gasteiz and Bilbao.

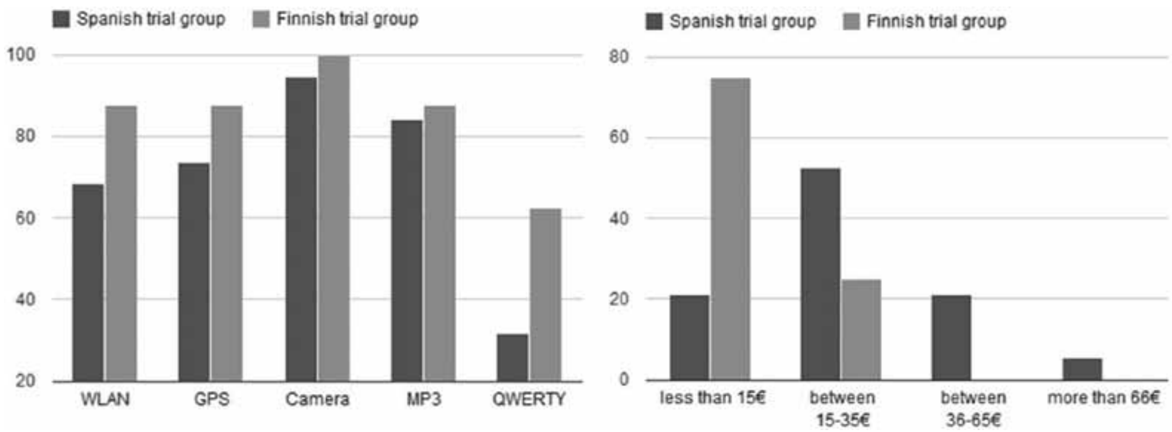

Figure 24.4 a) Personal phone features, b) Monthly spending on personal phone

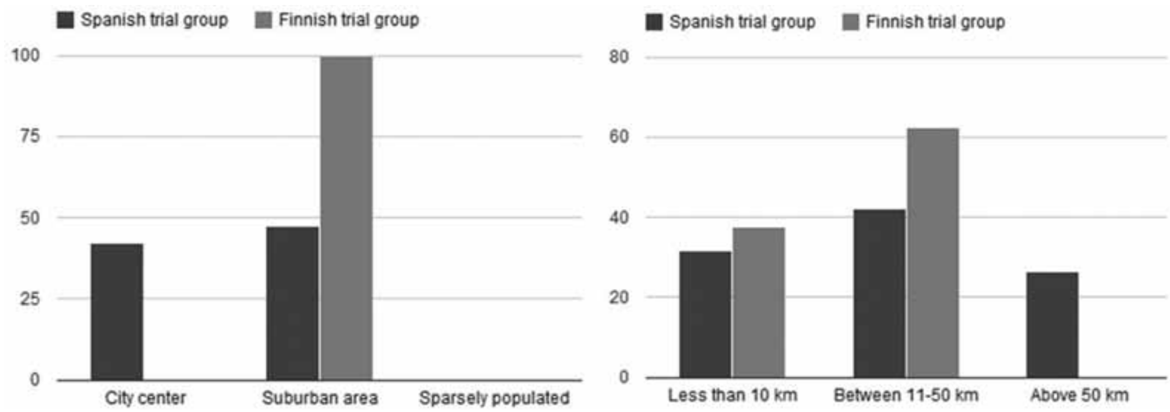

Figure 24.5 a) Home locations, b) Daily travel distance

Field Trials

A technical and functional explorative field trial was executed in Espoo (Finland) and Bilbao (Spain) to obtain necessary data for the MUGGES evaluation. Whereas the technical trials aimed to evaluate the peer-to-peer concept and the location technology, the functional trials focused on the evaluation of usage patterns.

The MUGGES infrastructure in both trials was provided from a server installed and operated in Spain (see Figure 24.6). Because all time-critical MUGGES tasks were handled directly between the devices, delays through the provision of MUGGES infrastructure services via the internet were negligible. A location model for both trial sites was created to symbolically represent all major indoor locations. These included 16 different places – for example, coffee places, vendor machines, and meeting rooms within the VTT[4] building complex and the engineering building of the University of Deusto. Each place had been equipped with visual markers (QR codes[5]) at convenient places – for example, walls close to the entry points to enable indoor positioning. For outdoor positioning, the standard GPS system was used. Participants were also encouraged to test the application freely elsewhere in the city so as to gain as much information as possible for technical and functional evaluation. In order to achieve a critical mass of mugglets for the service discovery the trial area was narrowed down to a set of shared and frequently visited places identified in an interview with all participants before each experiment. For the field trials, users were given Nokia 5800 XpressMusic touch screen smartphones with preinstalled and preconfigured MUGGES software. All phones had a small touch screen, embedded GPS, and a prepaid 3G/3.5G data connectivity that allowed 0.4–6 Mbit/s downlink data transfer. The MUGGES software included the MUGGES creation and execution kit to create and consume mugglets.

At each location, the study began with a kick-off meeting during which the MUGGES system was presented and demonstrated. Afterwards, participants were able to experiment with MUGGES in a one day training session, also to achieve truly informed consent about all aspects of the system, including data sharing. In each trial site different indoor and outdoor experiments were organized, which all concluded with a small competition at the end. In early phases of each trial participants were asked to create and consume muggesNotes, whereas in later stages they were asked to preferably utilize mashup mugglets. The competition was conducted to emulate a stress test for the MUGGES infrastructure. This was achieved by rewarding highly active users or users with the largest or most popular mashup mugglets. During and after the trials, data from the following sources were collected for the evaluation:

- *Mixed-mode mobile surveys*: An online questionnaire was designed which each trial participant was asked to answer before and after the experiment. Each dimension of the questionnaire was further defined through several MUGGES specific aspects. Participants were asked to respond to questions on a five-point rating scale, from *strongly agree* to *strongly disagree* (see Table 24.2).

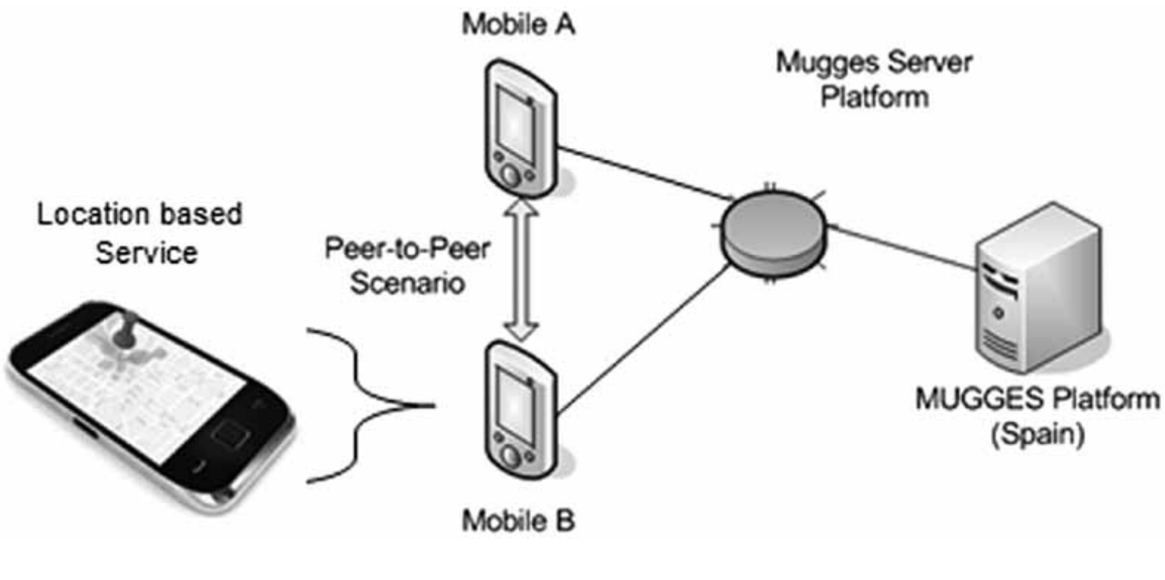

Figure 24.6 Technical infrastructure

Table 24.2 Questionnaire items with underlying dimensions and indicators

Dimension	*Indicator*	*Measurement*
Usefulness	Service creation	Sufficient service creation support?
	Service provision	Importance of service provision?
	Search power	Search tools powerful enough?
	Orientation benefit	Benefit for finding places, people, and information?
	Networking benefit	Benefit for meeting new people, coordinate meetings, and knowledge sharing?
Usability	Platform user interface	Attractivity of MUGGES Interface?
	Mugglet user interface	Attractivity of Mugglet Interface?
	Interface learning	Easiness to learn MUGGES usage?
	Interface efficiency	Satisfaction with user interface efficiency?
	Interface memorizing	Easiness to remember user interface interactions?

This online questionnaire was further complemented by open questions to obtain additional information – for example, suggestions from the study participants.

- *Event and error logging*: During the study a data logger software that was installed on the smartphones recorded MUGGES events and error messages. These data were later used to reconstruct MUGGES usage, usage contexts, and problem situations. After each experiment the log files were collected from the cellphone and uploaded to a repository on the internet. For ethical reasons, user identifying data (e.g. student name) and MUGGES log file data (e.g. mugglet specific events like taking a photo) were strictly separated.

RESULTS

Technical Acceptance Analysis

In order to present the overall user acceptance of the MUGGES system in one single figure, all measurements are represented in a radar chart. The center of the chart represents values indicating high user acceptance and the edge of the graph low user acceptance. Figure 24.7 shows the feedback for the Spanish user group. One line represents the first overall impression the MUGGES system left after an initial introduction and another line the overall long-term benefit perceived by all study participants towards the end of the trial. In the following we will analyze each dimension and combine them with the feedback obtained through the problem reporting tool and focus interviews:

1. *Perceived usefulness*: All study participants saw great long-term benefits in the MUGGES concept. The creation, provision, and discovery of personal services is definitely seen as useful in an everyday life scenario, as all these service management aspects were rated with 2.0 or even better. Mugglets seem to improve participants' orientation in cities (mean value of 1.5) and encourage networking between people (mean value of 1.5).
2. *Perceived usability*: For the usability dimension we separated user interfaces of the MUGGES platform from mugglets, as they are designed differently. Whereas the mugglet user interface has been well designed for mobile usage, people were disappointed with the service creation wizard. Obviously, pictures from the platform user interface looked more appealing on the MUGGES presentation and the task flow appeared more efficient during the demo (see mean value difference of 2.25/3.25 between first time and long-term impression). Developers felt that the service creation process was quite complex and thus was best represented through a wizard approach. The positive user feedback regarding interface learning (M = 1.4) and interface memorizing (M = 1.3) showed that a guided service creation approach was welcome. Nevertheless, the user interface was not completely designed from an end-user´s perspective, as it did not consider sufficiently the efficiency (M = 3.6) to create micro services. Task efficiency (e.g. time to create a service) is a highly critical aspect especially in situations while moving from one place to another.

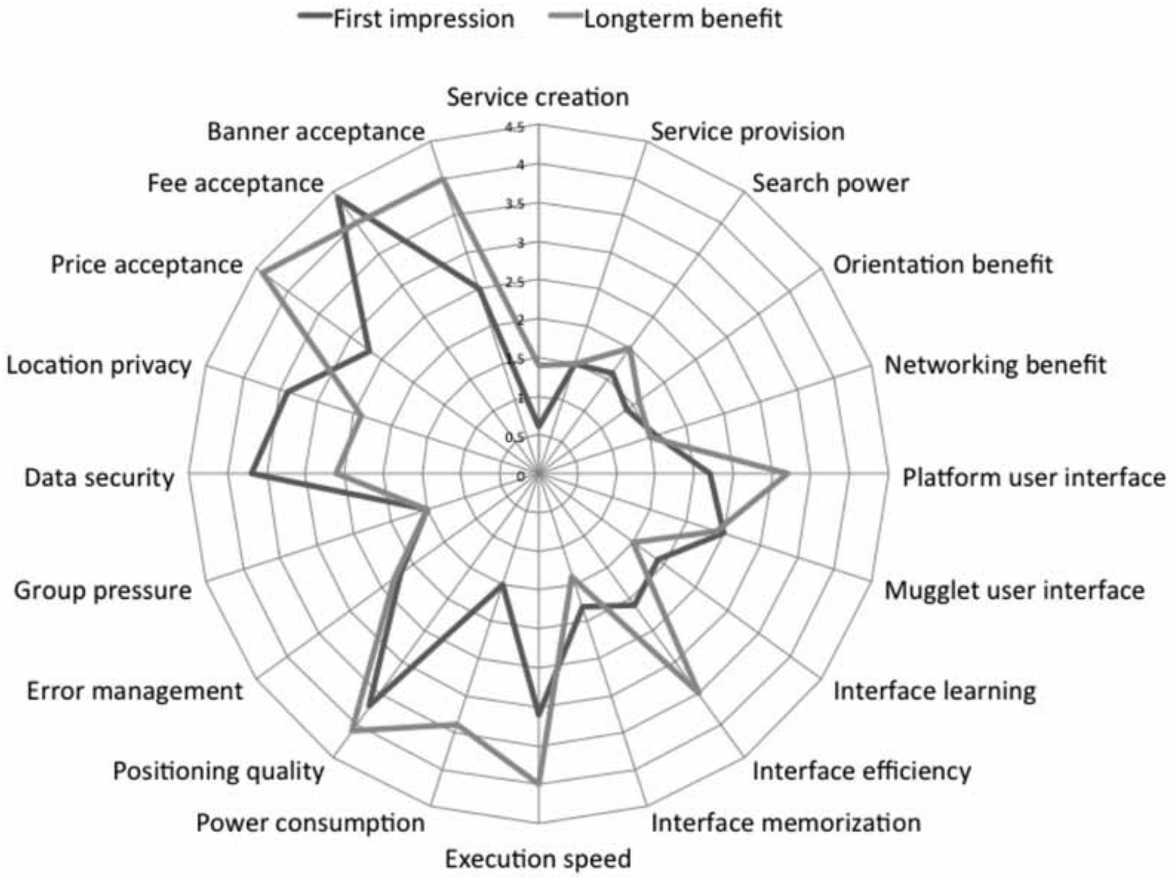

Figure 24.7 Comparison of first and long-term impression

Source: questionnaire data of Spanish study.

Log Data Analysis

Log data analysis has long been a fruitful method of internet-based and mobile research (Reips, 2006; Reips and Stieger, 2004). Based on the data obtained during the study, we analyzed MUGGES usage and its workflow. Mugglet usage was the highest (90 created mugglets per day) in the initial days of the study and dropped slightly in the remaining time (around 75 created mugglets per day). During weekends MUGGES was rarely used, since many students were living outside of the trial area. Far away from the trial area, the spatial coverage of mugglets was too low and the social networks supported with MUGGES too sparse to create sustainable interest to use the system. Also, the technical support was sometimes not available when MUGGES was not working properly. From the interviews performed at the end of the study, it was inferred that most of the study participants would use Mugglets once a day. This is a value similar to other social media applications of this type (Chan et al., 2014). Study participants mentioned distractions from the weather, the environment, and unstable implementation as the biggest and major reasons to refrain from MUGGES usage. Mugglet creation, provision, discovery and consumption showed the following:

1. *Mugglet creation*: During the Finnish and Spanish studies a total of 536 (149/387) mugglets were published. In the following we take a closer look at the spatial distribution of the MUGGES activities in the area of Bilbao (Spain) and Otaniemi (Finland). The location information recorded during creation-and-editing events is used to visualize these MUGGES activities. Figure 24.8 visualizes spatial usage patterns.[6] The size of a circle is correlated with the number of similar events in that location. Most creation events were centered around the university campus and the VTT buildings, which had been equipped with indoor location mechanisms like the visual

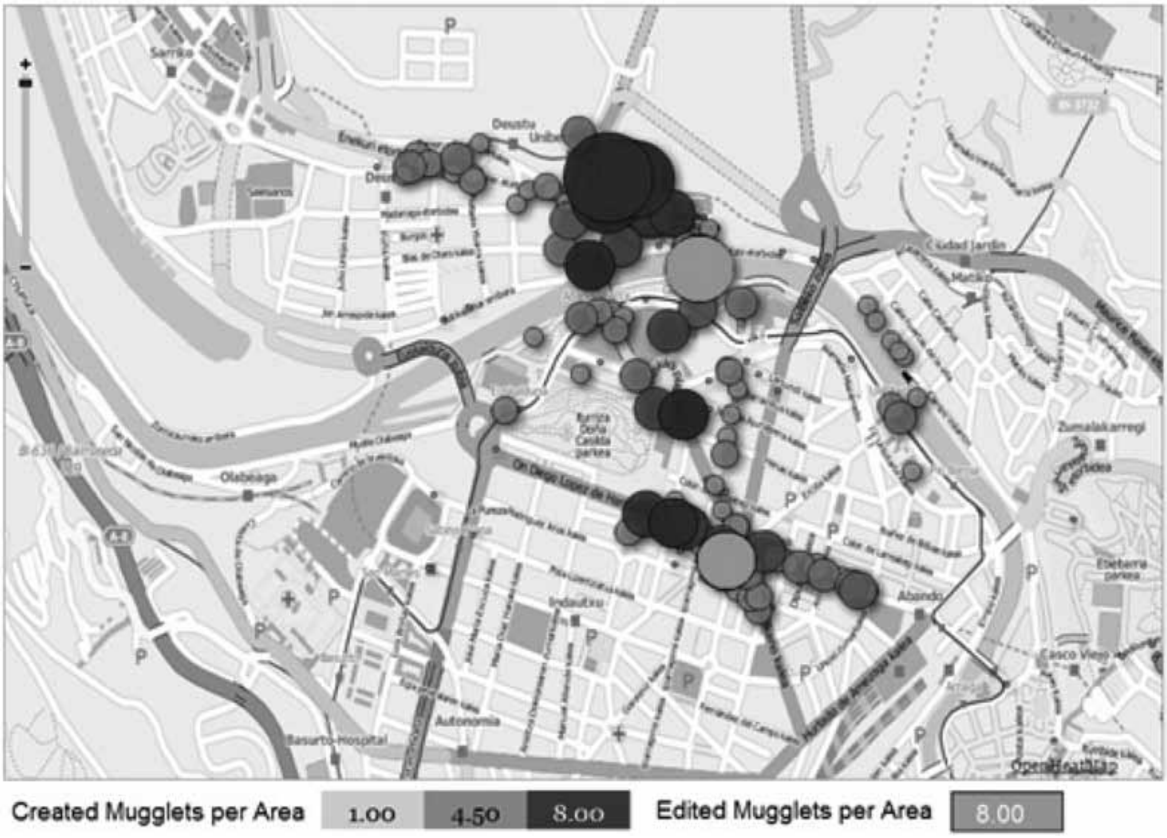

Figure 24.8 Creation and editing hotspots in Bilbao. The circle size corresponds with the number of similar events in the same location

Source: logging data of Spanish study.

markers. Participants also explored the surrounding neighborhoods. These were sports places (e.g. a soccer field), leisure places (e.g. coffee shops and bars), and in some cases even participants' individual home locations. One striking aspect is that the hotspots observed were much more widely distributed for Spanish participants. We put this down to 1) a larger group size, 2) better weather conditions, and 3) technical reasons (e.g. redesigned creation wizard and improved robustness) as the service creation process in the Spanish version was significantly shorter and thus occurred more spontaneously. In both groups, most mugglets were of the type muggesNotes, 84% in Otaniemi and 53% in Bilbao. This large proportion of muggesNotes is not surprising because they represent the basic building blocks of mashup mugglets. Other mugglet types were created as follows. In Finland there were 7% muggesJournal mugglets and 6% muggesTrail mugglets, and in Spain 30% muggesJournal mugglets and 30% muggesTrail Mugglets (see Figure 24.9a). The significant difference among mashup creation in Otaniemi and Bilbao can be explained by the fact that the creation wizard for mashups was significantly improved before the Spanish group began the study. During the interview after the trials, users felt that mashup creation was a powerful feature and encouraged us to extend MUGGES by allowing the reusage of notes from other users, and by pre-creating mugglets for well-known places. Figure 24.9b shows that most mashup mugglets contain between two and seven mugglets, while the majority of all mashup mugglets had a length of four muggesNotes. As the mugglet creation process represents a certain effort and the overall usage times during a move from one place to another are usually limited, mashup mugglets in general may not grow very large. Participants reported that their devices became significantly slower with the increasing size of the mugglets.

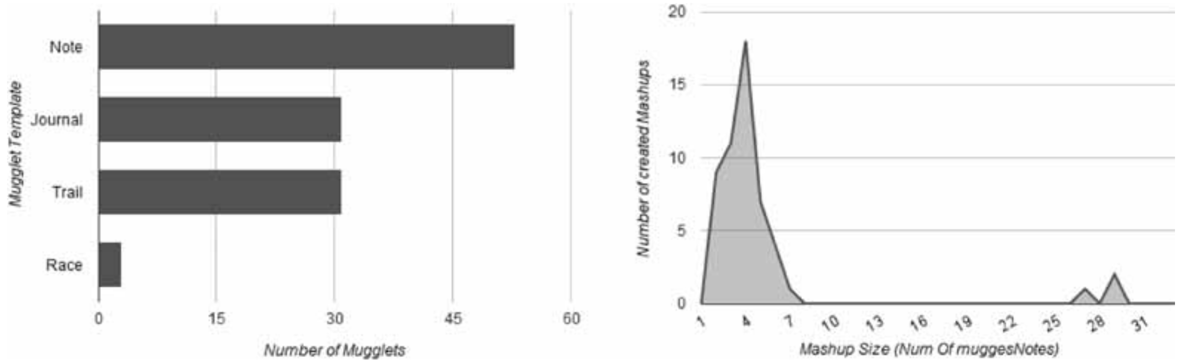

Figure 24.9 a) Applied mugglet templates, b) Observed mashup size

Source: content data of Spanish study.

2. *Mugglet provision*: Originally mugglets were designed mainly for short-term usage. Surprisingly, mugglets were used for much longer times – only around 33% of mugglets were provided for several hours and 17% for several days (see Figure 24.10a). The remaining 50% were used for much longer. Study participants reported that they wanted their mugglets to be active for a longer time frame depending on the feedback they obtained from others (19%), the event related to the mugglet (6%), and the intended audience (6%, see Figure 24.10b).

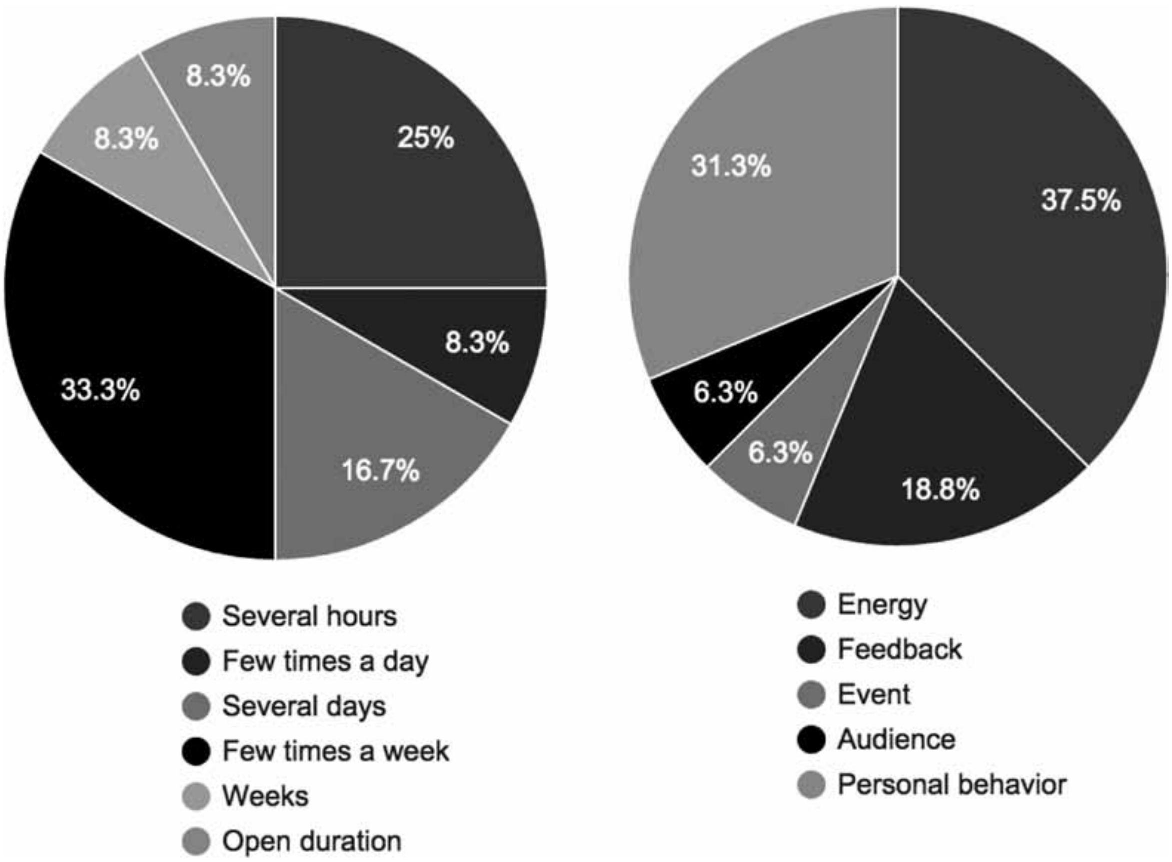

Figure 24.10 a) Measured provision duration and b) reasons to stop provision

Source: logging/survey data of Spanish study.

Most of the time the provision duration was limited by the battery consumption (38%) or execution speed. The popularity of mugglets can indirectly be measured by the number of subscribers. Only small friend groups of not more than two or three users subscribed to the majority of mugglets (see Figure 24.11). A small proportion (around 10%) of mugglets attracted a large audience of up to 15 people. Considering the fact that the study group size was 17 people, this is quite a large value. Even though the sample was small, there was clear evidence of participation inequality in the study. This rule in summary means that 'in most online communities, 90% of users are lurkers who never contribute, 9% of users contribute a little, and 1% of users account for almost all the action' (Nielsen, 2006).

3. *Mugglet discovery and consumption*: Data reveal that the MUGGES system was mainly utilized to coordinate pleasure activities during spare time periods in the afternoon and in Spain also during the night. MUGGES usage during work has been rather negligible as the location-based nature of mugglets is of most value while people are on the move. The majority of the searches in early trial phases were category based – for example, participants searched for muggesNote, as this was the simplest way of identifying adequate mugglets with only a few out there. With an increasing number of mugglets the result lists became longer and the identification of the right mugglet more difficult on the small screen of the smartphone. Study participants compensated for this by exploring more advanced search methods – for example, the keyword-based search (15%) or the map-based search (31%, see Figure 24.12a). Specific preferences for topics could not be detected (see Figure 24.12b). People showed similar interests in all different daily city activities – for example, shopping, restaurants, sports, and nightlife.

Discussion

Interpreting the service creation, provision, and consumption patterns revealed further aspects, which were often backed by the feedback we obtained from the interviews.

First, the number of created mugglets found at a certain location depended strongly on the time taken to create them, especially during bad weather conditions or in darkness. For instance, during rain people looked for spaces where they could take shelter whereas during the night people seemed to prefer spaces with light – for example, a bus station. Heterogeneous creation and editing event locations showed that people in many cases did not have enough time to complete the mugglets. One major reason was the limited responsiveness of the touch screens at the time, when touch screen technology was in its early stage of development. The Nokia 5800 XpressMusic was released in November 2008 and used a resistive touch screen technology that relied on a stylus as an input device instead of capacity based touch screens common in today's smartphones that can

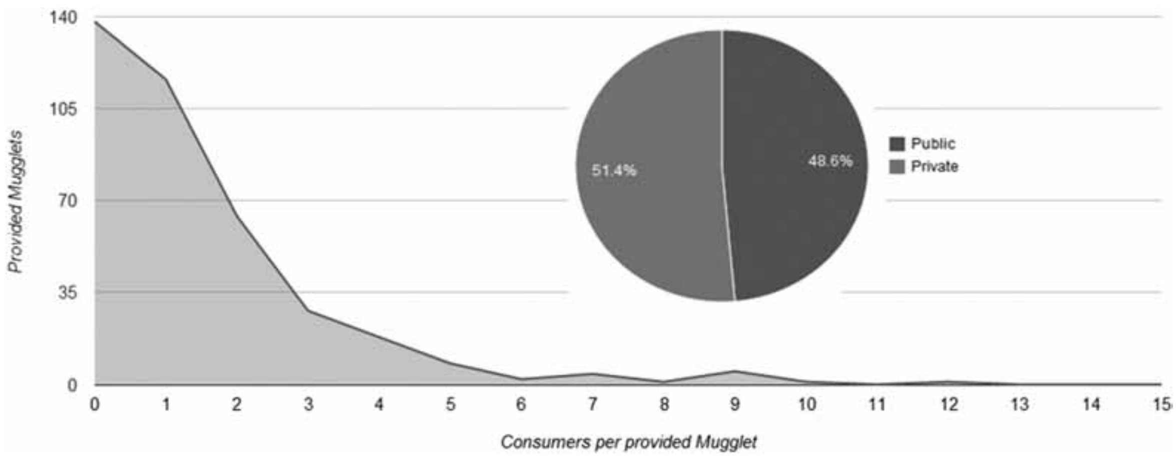

Figure 24.11 Community size of correlated mugglets

Source: logging data of Spanish study.

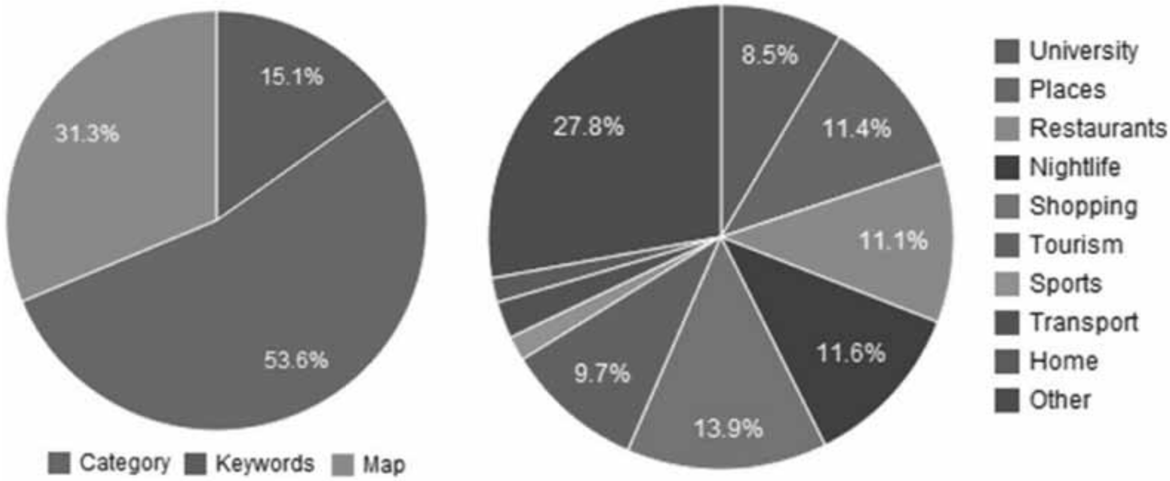

Figure 24.12 a) Applied search techniques and b) preferred search topics

Source: logging data of Spanish study.

be used with fingers. People compensated for this problem through a two-step creation process, first taking a photo and tagging it with the current location and then editing the content in a more convenient location – for example, at restaurants, cafes, or public transport stops. For other social media like Facebook and Instagram, this behavior observation was less obvious as the overall mugglet creation process was more complex and thus took more time. Because the participants often employed such a two-phase task flow for creating and editing mugglets, there was a clear need to provide private work space, which enabled users to publish mugglets only when they were finalized. Beyond that, participants suggested replacing the creation wizard with a simple form, as scrolling was faster than skipping through multiple wizard screens. A consequent reuse of user profile data and community data were further suggestions to make the creation process more efficient.

Participants created mugglets not only for their friend groups but also for larger audiences (49% public mugglets). Attracting a larger audience is not easy and requires a lot of effort – for example, nice photos, interesting descriptions, or frequent updates. During focus interviews people requested social features like mugglet recommendations/ratings, but also real time features like update notification to give authors better means to address a larger audience or increase the popularity of their mugglets. A frequently mentioned key strength of MUGGES has been that it keeps people much more effectively connected – for example, by sharing popular locations and paths while on the move. An analysis of the technical context during the mugglet provision demonstrated that the energy usage and bandwidth consumption often limited the provision duration. An alternative implementation could consider a hybrid peer-to-peer approach where mugglets are hosted in the cloud but still managed from the users' mobile phone. This solution would probably have resolved many shortcomings related to peer-to-peer communication.

During the focus interviews study participants told us that they envisioned two different mugglet discovery use cases. In the first case participants tried to explore mugglets by topic in order to decide which places to visit. This mugglet exploration task happened mainly in indoor locations – for example, university, or VTT campus areas where working with a mobile device was convenient. In the second case, participants often explored the surrounding neighborhood (outdoor locations) with the map-based search method to see what other attractions existed in the proximity.

CONCLUSION

With entering the mobile sphere the Internet has well advanced into changing science (Reips, 2008). In this chapter, we presented a framework for evaluating and ultimately designing innovative social location-aware services for cellphones. As an example, we reported on an evaluation of the MUGGES project. A living lab is an open innovation ecosystem where different technology providers and end-users collaborate in a realistic environment with the goal to achieve the best possible product quality. In order to get a general idea about how people accept the super-prosumer model and perceive the peer-to-peer and location-based concept behind MUGGES, we conducted a questionnaire and combined the data with log data. The first impression after the kick-off meeting was very positive because participants perceived the super-prosumer concept as a very powerful feature. Even though the user interface impressed the study participants in the beginning, people detected several shortcomings later, especially some related to the creation wizard, the mugglet query tool, and the peer-to-peer service provision concept. Interestingly, doubts about data security and location privacy were not confirmed, as mugglets do not reveal personal information.

In addition to survey data, we also exploited log files and user content to compare users' perceptions with real MUGGES usage. Moreover, we analyzed individual MUGGES functions like service creation, provision, discovery, and consumption. For each function we examined usage rates, spatiotemporal usage hotspots, community, and structures. With the spatial analysis, we were able to detect specific usage hotspots, and the distribution characteristic revealed to what degree the services were used in a planned or spontaneous manner. Looking at the community structure of individual mugglets confirmed that subscriber communities were rather small. Interestingly, people liked to create mashup mugglets as they seemed to provide more complex information and were more easily created by reusing existing muggesNotes. No specific mugglet topics were discovered during the study, suggesting that MUGGES was imaginable for all sorts of city activities.

Altogether, we found that the living lab approach worked very well to improve a complex infrastructure like MUGGES. During the study, it became clear that questionnaire-based feedback alone cannot deliver data on the same level of granularity as its combination with log data and user perceptions. Combining several methods is more likely to reveal the real strengths or weaknesses of a product.

Notes

1 Low cost usability testing, www.usertesting.com
2 Morae usability testing tools from TechSmith, www.techsmith.com
3 Global Positioning System, satellite-based navigation system.
4 Radio-frequency identification, wireless non-contact-system for the purpose of object identification.
5 Quick Response Code, optical machine-readable two dimensional barcodes for object recognition.
6 www.openheatmap.com/

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REFERENCES

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Englewood Cliffs, NJ: Prentice-Hall.

Becker, C., & Dürr, F. (2005). On location models for ubiquitous computing. *Personal and Ubiquitous Computing*, *9*(1) 20–31.

Bergvall-Kåreborn, B., Ihlström Eriksson, C., Ståhlbröst, A., & Svensson, J. (2009). *A milieu for innovation: Defining Living Labs*. In Proceedings of 2nd ISPIM Innovation Symposium: *Simulating Recovery*, New York, December 6–9.

Boase, J., & Ling, R. (2013). Measuring mobile phone use: Self-report versus log data. *Journal of Computer-Mediated Communication*, *18*(4), 508–519.

Bruns, A. (2008). *Blogs, Wikipedia, Second Life, and beyond: From production to produsage*. New York: Peter Lang. Retrieved from www.loc.gov/catdir/toc/ecip084/2007046097.html

Buchanan, T., & Reips, U.-D. (2001). Platform-dependent biases in online research: Do Mac users really think different? In K. J. Jonas, P. Breuer, B. Schauenburg & M. Boos (eds) *Perspectives on internet research: Concepts and methods*. Retrieved from www.psych.uni-goettingen.de/congress/gor-2001/contrib/buchanan-tom

Cassady, J. C., & Johnson, R. E. (2002). Cognitive test anxiety and academic performance. *Contemporary Educational Psychology*, *27*(2), 270–295.

Chan, T. K. H., Cheung, C. M. K., Lee, Z. W. Y., & Neben, T. (2014). *The urge to check social networking sites: Antecedents and consequences*. In Proceedings of 18th Pacific Asia Conference on Information Systems (PACIS), Chengdu, China.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, *13*(3), 319–340.

Froehlich, J., Chen M. Y., Consolvo, S., Harrison, B., & Landay J. A. (2007). *MyExperience: A system for in situ tracing and capturing of user feedback on mobile phones*. In Proceedings of MobiSys. San Juan, Puerto Rico. doi:10.145/1247660.1247670.

Götz, F. M., Stieger, S., & Reips, U.-D. (2017). Users of the main smartphone operating systems (iOS, Android) differ only little in personality. *PLoS One, 12*(5): e0176921.

Jensen, K. (2009). RECON: Capturing mobile and ubiquitous interaction in real contexts. In Proceedings of MobileHCI, Bonn, Germany. doi: 10.1145/1613858.1613948.

Kaasinen, E. (2003). User needs for location-aware mobile services. *Personal Ubiquitous Computing*, *7*, 70–79.

Klein, B., López-de-Ipiña, D., Guggenmos, C., Pérez, J., & Gil, G. (2014). User-aware location management of prosumed micro-services. *Journal of Interacting with Computers*, *26*(2), 118–134.

Klein, B., Perez, J., Guggenmos, C., Pihlajamaa, O., Heino, I., & Del Ser, J. (2012). Social acceptance and usage experiences from a mobile location-aware service environment. In Mobile Lightweight Wireless Systems, Third International ICST Conference, MOBILIGHT 2011, Bilbao, Spain, May 9–10, 2011. Revised Selected Papers (pp. 186–197). Springer Berlin Heidelberg.

Malhotra, Y., & Galletta, D. F. (1999). Extending the technology acceptance model to account for social influence: Theoretical bases and empirical validation. In Proceedings of the 32nd Hawaii International Conference on System Sciences, (pp. 1–14). Hawaii.

Mulder, I., Ter Hofte, G., & Kort, J. (2005). SocioXensor: Measuring user behaviour and user eXperience in conteXt with mobile devices. In Proceedings of Measuring Behavior, the 5th International Conference on Methods and Techniques in Behavioral Research, Wageningen, the Netherlands, pp. 355–358.

Nielsen, J. (2006). *Participation inequality: Encouraging more users to contribute*. Retrieved from www.useit.com/alertbox/participation_inequality.html

Raento, M., Oulasvirta, A., Petit, R., & Toivonen, H. (2005). Contextphone: A prototyping platform for context-aware mobile applications. *IEEE Pervasive Computing*, *4*(2), 51–59.

Reips, U.-D. (2006). Web-based methods. In M. Eid & E. Diener (eds) *Handbook of multimethod measurement in psychology* (pp. 73–85). Washington, DC: American Psychological Association.

Reips, U.-D. (2008). How Internet-mediated research changes science. In A. Barak (ed.) *Psychological aspects of cyberspace: Theory, research, applications* (pp. 268-294). Cambridge: Cambridge University Press.

Reips, U.-D., & Stieger, S. (2004). Scientific LogAnalyzer: A web-based tool for analyses of server log files in psychological research. *Behavior Research Methods, Instruments, & Computers*, *36*(2), 304–311.

Rogers, E. M. (2003). *Diffusion of Innovations*, 5th edn. New York: Free Press, Simon and Schuster.

Shevchenko, Y., Kuhlmann, T., & Reips, U.-D. (2021). Samply: A user-friendly smartphone app and web-based means of scheduling and sending mobile notifications for experience-sampling research. *Behavior Research Methods*, *53*(4), 1710–1730.

Stieger, S., & Reips, U.-D. (2010). What are participants doing while filling in an online questionnaire: A paradata collection tool and an empirical study. *Computers in Human Behavior*, *26*(6), 1488–1495.

Technical Acceptance Model. (2016). *In Wikipedia*. Retrieved from https://en.wikipedia.org/wiki/Technology_acceptance_model

Venkatesh, V. (2000). Determinants of perceived ease of use: Integrating control, intrinsic motivation, and emotion into the technology acceptance model. *Information Systems Research*, *11*(4), 342–365.