A Diary Study on Annotating Locations with Mixed Reality Information

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ABSTRACT
With advanced sensor technologies and tools for content creation, current mobile devices possess features for providing information services based on user’s location. There are several services for geographically pinned user-generated content focusing on providing information to users in unfamiliar locations. However, information needs regarding location-based content services in the familiar everyday context have so far been quite little researched. Our research entailed a 12-day user study where nine participants kept a diary, in which they reported needs for annotations of locations they had come across in various day-to-day situations. Based on our results, we present design implications for annotation services, taking into account the user needs in various daily situations. The results show that the services should support flexible controls of the visibility of annotations, notifications about selected annotations within the vicinity, and easy remote annotations. In addition, the system should support collective and living annotations that can be contributed by several users.

Categories and Subject Descriptors
H.5.2. [Information interfaces and presentation (e.g., HCI)]: User Interfaces

General Terms
Design, Experimentation, Human Factors

Keywords
Mobile device, location-based content, location-awareness, mixed reality, user study, user needs, design guidelines

1. INTRODUCTION
Many popular websites provide a means for publicly sharing comments and reviews regarding events, products, and services, such as hotels and restaurants (e.g. www.yelp.com and www.epinions.com). People are increasingly relying on such user-generated information instead of that created by professionals or public authorities [4]. A large portion of this user-generated content is specific to a certain location, thus often being created and accessed through map-based interfaces. In addition, location-aware mobile services that provide reviews of restaurants close to a user's current location have emerged (e.g. Zagatuntu at www.zagat.com). Similarly, people share places they check in and tips about them in popular web services (e.g. www.foursquare. com and www.facebook.com).

The studies on more private content, such as messages and reminders indicated that they could also benefit from being bound to location [9,19]. For example, being able to define the delivery of a message based on the recipient’s arrival at the certain location helps in ensuring that the message is received at a convenient time and place.

Previously noted uses of geographically defined content can be viewed as ways to annotate locations. Tying digital content to a geographical location is made possible by the global positioning system (GPS), which is also becoming a standard feature in mobile devices. Inclusion of a compass and accelerometer in recent high-end mobile phones is enabling even more engaging views and interfaces to the location-based digital content. One example of such an approach is mixed reality (MR), (i.e. integration of the information from both real and virtual worlds where physical and virtual objects complement and interact with each other) [1]. The location-based content can be shown, for example, in real-time on top of the camera view of a mobile phone, or on top of 3D models or satellite images, as in Google Earth. MR visualizations have been suggested as a way to guide users’ mindsets toward location-based interaction with annotation services [2,17]. All in all, these new approaches of integrating digital information on real-world locations hold the potential to revolutionize the way information is presented to and accessed by people.

There exists a large body of research on enabling technologies related to location-awareness and MR. Both location-based content and MR visualizations are often suggested to support for example tourists in unfamiliar locations, or for entertainment purposes [13]. However, little is known about what kind of location-specific information content people would consider useful or pleasurable in the various daily situations.
A large part of people's lives consist of running daily errands, organizing family life, keeping up with friends, and relaxing with their hobbies. Services designed to support people's goals and routines in such contexts can provide a great deal of practical value for a large group of people. The everyday aspect, however, has seldom been focused on, even though it is the most common one; considering both the frequency of use and the extent of application areas.

In consideration of the above-mentioned, we conducted a user study to better understand with what and why people would annotate locations with mixed reality information, especially in the context of everyday urban life. Based on these results, we propose design implications for the development of future location-based annotation systems supporting everyday life.

2. RELATED RESEARCH
To discuss the motivation for creating location-based annotations, we first provide a general background related to creating and managing user-created digital content. This is followed by descriptions of prior research related to location-based annotation systems, including the systems that are based on MR visualizations.

2.1 Digital Content Management
Personal information management has been extensively studied over the past decade. Research has been conducted on user-created media content, digital memories, and photo sharing. Most of this research has focused on visual content, such as photos and videos (see [10,12,13]).

Various motivations for sharing self-created content have been presented: constructing personal and group memories, creating and maintaining relationships, self-expression, self-presentation, and for functional purposes [5,20]. Most content is very social by nature, depicting friends, family, and togetherness at various social gatherings. In other words, sharing content can be seen to strengthen social ties and bonding, and to provide the creator with a way to express oneself. Understanding these general motivations for creating and sharing such content served as a basis for analyzing the needs behind the user-created annotations in this study.

2.2 Location-based Annotation and Messaging
Earlier research has produced various systems for demonstrating location-based interaction (e.g. location-based messaging [2,6,9,17] and reminders [11,19]). Naturally, the usage of the systems in these trials has been affected by the design choices made in building the systems, especially the decisions about sharing options and notifications. In addition, selecting laptop as the platform has restricted the use for the situations it has been designed to support. Selecting a mobile device as the platform, instead, has enabled more spur of the moment usage. The accuracy of selected positioning technology has also dictated the usage. These studies, and the effect of the design decisions, are further discussed below.

The pioneering system, E-graffiti, was built for students to annotate locations at their university campus using their laptops [2]. The trial users could direct the notes to specific users or make them public. Most notes were directed to specific users, indicating that users are more comfortable and willing to share content with a limited group. As only a few of the notes related to the location, it seems the system lacked the support for the location-inspired thinking when creating notes. This emphasizes the importance of representing the location and context in the user interface (UI) of the service in supporting the location-based mindset of the users.

Another laptop and Wireless LAN positioning-based system, GeoNotes, focused on public location-aware communities, and was designed to encourage discussion about geographical locations [6]. Only public notes were allowed in the system, to provide more content for the users to browse [16]. In the trial, they found that by far the largest category of notes was motivated by a general desire to chat with other users, including those outside the user's normal circle of friends. Furthermore, many of the discussions were not really about locations but rather about ongoing social activities [15]. These results show that such notes often relate to ephemeral targets in the given location, and that the awareness of the social context is an important motivator for the content creation.

The designers of InfoRadar [17] built a location-based messaging system running in a personal digital assistant (PDA) connected to an external GPS, and GPRS receiver. They improved on the E-graffiti and GeoNotes by adding remote reading and a radar view of the messages to guide the users toward a location-based mindset. However, trial users' experience was hindered by not noticing the nearby content while it was still relevant, since no notifications were implemented. Test users also commented that the radar view was insufficient for navigating to the location of the content.

Another system based on PDAs and GPS, designed to improve on E-graffiti, was Context Aware [3]. It was designed for university students to provide location-based information for visitors to their campus. The system implemented audio alarms of nearby new notes, but the test users took very little advantage of them, at least during the first-time use or a tour lasting less than an hour. The missing navigational support in the UI also came up as an issue that the test users struggled with.

While the systems described above mainly focused on public notes, a system called DeDe [9] focused on private messaging. It allowed the user to define the delivery of a multimedia message by, for example, time, the recipient's location, or people around them. In the trial with secondary school students, location was the most popular attribute used in defining the delivery of the messages. Creation of the location-based messages was shown to require detailed knowledge of the recipients' future plans and would therefore be sent mainly to the closest friends. In addition to pure messaging, DeDe was used in creating reminders for friends about common tasks.

In contrast with the communication-oriented services described above, Place-Its was built to study the use of location-based reminders [19]. Regular time-based reminders are currently often set based on the prediction of when one will most likely be in the related location. Similar predicting could be seen in the trial of Place-Its. The test users of Place-Its were able to infer from arriving at a location that they would likely have more time for a certain task or that a certain person would be nearby [19].

PlaceMail, built by Ludford et al. [14] for similar purposes as Place-Its, was designed to display lists of relevant reminders for a location to support shopping lists, to-do lists, etc. that were identified as important in their pre-study. It also improved on the accuracy of providing the notification about a close-by remainder.
2.3 User-created Annotations in MR Systems

In the related literature, a few descriptions exist of systems that enable annotation in augmented reality, but studies about user trials with them have not been published. Already in the 90’s, Feiner et al. [7] created a system for placing UNIX X windows into the physical locations viewable with a head-mounted display. They used ultrasonic and magnetic trackers to accurately recognize the position of the user to display the windows lined up with the real-world view on the head-mounted display.

Rekimoto et al. [18] used infrared beacons and 2D markers for identifying the annotated object, and a wearable see-through display for showing the content. These researchers argued that the 2D markers help users find the digital content and should not be replaced with markerless technologies, even if it would be technically possible.

Recently, publicly available systems have emerged that allow annotations to be shown on top of a camera view of a mobile device. Wikitude Me (www.wikitude.org/) allows the creation of text annotations on the website, and related mobile application allows viewing them on top of the mobile phone camera view. Sekai Camera (www. sekaicamera.com/) enables the placing of text, audio notes, and images via iPhone, and uses a camera view for browsing them. Junaioc (www.junaioc.com/) supports 3D models in addition to the common media types.

The above publicly available systems only provide mobile annotation functionality at the user’s current location. However, annotating from distance has been considered in the research already, and methods for defining the distant location vary from pointing the location from maps and 3D models to pointing it with laser distance meters [21].

3. DIARY STUDY

Our main research goals were to understand the large variety of uses people might have for digital location-based annotations in their everyday life, and what kind of requirements these uses would pose for such a system. In more detail, we studied what kind of motivations users have for creating annotations and what kind of content the annotations would contain. We were interested both in the media types included to the annotations and the semantic nature of the content. We also wanted to assess what users would annotate, the size range of the physical targets they would attach the annotations to, and whether the targets would be dynamic in relation to location. Furthermore, we wanted to investigate the temporal dimension of the annotations (i.e. what kinds of needs there are for annotations that change or disappear over time).

Earlier studies on use of location-based annotations have focused on evaluating existing systems that have been designed for certain kind of use. We wanted to explore the possible uses without implementation limitations and created as open a setting as possible to complement the earlier research. Our study participants kept diaries of the annotations they would like to create if an “ideal” system was available. Even though a weakness of the diary method is the missing interaction with the other users of such an imaginary system, our study’s open setting was regarded as complementing earlier research in a valuable way. Not limiting the annotations based on features of existing systems was expected to enable more diversity in participants’ annotations.

We kept the setting open for all location- and context-related annotations, including MR annotations. In order to support creative thinking and the MR approach, the participants were asked to illustrate their diary annotations with paper photos that they were free to scribble on. This method provided the kind of freedom for participants to express their ideas and needs, which we could not have achieved by observing usage of any existing system. Also, since we were interested in the annotations participants would create in their normal everyday life, the diary method provided us more valid data than just shadowing participants for a short period of time.

3.1 Methodology

The user study was conducted with nine participants in Finland in July 2009. Participants from two major Finnish cities (Helsinki and Tampere) kept a paper diary for 12 days, reporting what kind of annotations they would create in their normal everyday life. Group interviews were conducted with these participants both at the beginning and end of the study in both cities. In the first group interview, participants filled in a background questionnaire and were introduced to augmented reality services.

We asked the participants to think about a service that would allow them to place annotations to locations. Other users of the service would see these annotations in their mobile phones when they came to the same location. Content of the annotations could be text, photos, videos, audio, music, or whatever participants wanted to imagine. It was emphasized that the ideas did not have to be feasible. Participants were guided to use the diary on a daily basis, but they were not required to carry it with them at all times. They were instead given small notepads to encourage them to make notes of every idea they came up with.

![Figure 1. Diary, instructions, and mobile printer provided for the participants](image)

3.1.1 Example Annotations

To provide concrete experience of finding location-based annotations, we applied the idea of cultural probes introduced by Gaver et al. [8]. In order to provoke inspirational responses about the concept of location-based annotations, we created two packages of stimulus material and questions related to two different locations. In both cases, participants had time to answer the given questions in the context before returning their answers.

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Participants received the first package in a participatory group session that was carried out in a museum in the first interview. They were given envelopes containing paper examples of annotations related to the museum (i.e. flyer of the current exhibition, a gift ticket to it, and a related postcard) and a few questions related to the material. They were then given time to see the exhibition and to answer the questions. At the end of the session they were interviewed about their experiences.

On day seven of the diary period, participants were given the second hands-on experience of finding location-based annotations. Participants were informed via SMS that they could find annotations left for them at a certain cafe and that the waiters there were instructed to give them an envelope with contents similar to the first session. The envelope included example annotations (i.e. reviews about the cafe, a note about lost sunglasses, an advertisement about a hobby club meeting taking place at the cafe and, a gift voucher supposedly left by a friend), and questions about their needs and preferences in browsing annotations.

3.1.2 The Diary
Diary entries about created annotations consisted of questions about the situation the annotation would have been created in (e.g. date, time and place; distance from the target; whether the participant had company) and about the annotation itself (e.g. target, motivation, description of the contents, including the used media types, lifetime). Entries also included information about with whom the participant would have liked to share the annotation and what kind of rights the participant would have given others to edit the annotation. The place, target, motivation, and description were open-ended questions, while the rest were multiple choice questions.

Furthermore, participants were asked to take a photo relating to the situation or the target they would attach the created annotation. To enable inclusion of these photos in their diaries, participants were given portable Polaroid PoGo photo printers. They took the photos with their camera phones or pocket cameras and printed them on stickers using the PoGo. At the end of the study, the photo printers were given to the participants as compensation for their efforts.

In addition to created annotations, situations where one would have queried location-based annotations were reported in the diary. Entries about the queries consisted of questions about the context (e.g. time and place, whether they were in someone else’s company), the target, what kind of information they desired about the target, and how far the target was from them.

As keeping a diary is not a usual part of someone’s daily routine, it would have been easy for participants to forget this task after a couple of days. Therefore, participants were reminded with SMS tasks to create annotations during the course of the study. They were asked to create an annotation related to their daily routine on day three, an annotation visible to anyone on day five, and an annotation related to their mood on day eleven. These served as further stimulus for participants to expand their perspective in contemplating and reporting their annotations. To identify these prompted entries from the spontaneous ones at the analysis phase, participants were asked to mark the entries related to the SMS tasks.

3.2 Analysis
The qualitative contents of the diaries were analyzed using a qualitative grounded theory approach. To classify the annotations by types, first the data were treated with open coding by three researchers, in order to identify the central themes and categories. Each annotation entry was labeled based on: (i) what its contents was about; (ii) what target it described; and (iii) what the interpreted motivation was for creating it. This phase was followed by axial coding to place each annotation in one or several of the recurrent categories (conducted by 2 researchers). Based on both the qualitative and quantitative data, we were able to understand the various uses for annotating locations behind the entries.

The group interviews were recorded and transcribed. Transcripts were read thorough to analyze, and design ideas and implications were written on post-its and attached next to the user data that inspired them. References to corresponding diary entries were also identified and used to explain the entries when the second group interview revealed more about the idea than the original diary entry. Furthermore, needs, expectations, and design ideas that had not been marked in the diaries were identified from the interview transcripts and listed. In addition, questionnaire data was compiled into tables and summarized and visualized.

3.3 Participants
In order to recruit active and creative participants who would most likely use such a location-based annotation system if available, those who replied to our recruitment advertisement were screened using a web questionnaire. We then selected nine participants aged from 18 to 52 years (median 28 years). Two participants were male, and seven were female (skewed due to a couple of last-minute cancellations). They were active in sharing information (e.g. updating Wikipedia, keeping blogs, taking part in discussion forums on the web) or interested in LBSs (e.g. geocaching). This was considered important to ensure that the participants would share their annotation ideas in high detail in the diaries. Participants’ levels of technology orientation varied from an average user to highly-oriented, but all of them considered technology as necessary in their daily life. Five of the participants were somewhat familiar with the term “augmented reality”, but it was unfamiliar for the rest prior to participating in this study. Except for one participant, researchers were not acquainted with the participants beforehand.

4. RESULTS
The diaries consisted of entries that people would have created and reports on situations where they would have like to query location-based information. During the study, 95 annotations were created and 48 queried. Creation activity decreased during the study period (see Figure 2). Still, by reminding participants with SMS tasks, we managed to engage them to the activity for the 12 days.

4.1 Description of Annotations
4.1.1 Media Types Included
The diary form incorporated a table for describing the media items that would be included in the created annotations. The most popular media types were text and images. Seventy percent of the annotations included text, and 61% at least one image. The method where participants were asked to describe their annotation
ideas with text, photos, or drawings most likely made it easier to think of annotations consisting of these same media types. However, music (in 15%), other audio (in 15%), and videos (in 11%) were also used in a fair amount of annotations.

Sixty-eight percent of the media items included would have been done at the time of creating the annotation. Previously created media items were used much less: 15% from the internet, 12% from a personal computer, and only 4% from a mobile phone memory.

Figure 2. Number of created annotations per day. NB: Light grey bars indicate the days when participants were sent SMS tasks. Dates unknown (N/A) for eight created annotations

4.1.2 Targets of Annotations

The targets that the participants annotated during the study varied from large geographical areas to small portable objects. Based on the analysis, the target types listed below were identified. The number of queried annotations of the target type is included in parentheses after the number of created annotations. However, five of the created annotations and one of the queried did not have enough accurately defined targets to be categorized.

Exact locations: Only 10 (4) of the annotations were related purely to an exact location without the need to specify the target more precisely (e.g. “location where I found mushrooms” or “just before the highest ascent on my jogging path”).

Geographical Areas: 14 (9) of the annotations were related to a more or less well-defined geographical area. The size of the annotated areas varied from a schoolyard to a municipality, and the areas included both urban (e.g. railway station platform, marketplace, district in Helsinki) and natural areas (e.g. nature park, lake, jogging path).

Buildings or parts of buildings: These were the most popular targets, with 29 (16) annotations. Most of these targets were commercial: 13 (7) restaurants (or cafes) and 7 (3) shops. Annotations on buildings were targeted to also be visible and available from outside the building.

Indoor spaces: 16 (2) of the annotations were related to indoor spaces defined by surrounding walls, but were not related to any specific object within that space. Nine of these created annotations were related to either the creator’s or someone else’s home, or a room within it. Annotations added to indoor spaces were targeted to be available mainly from inside the space, as opposed to building annotations.

Factual annotation: Examples of factual annotations would include giving the location of a nearby parking lot, or a nearby petrol station. In our study, 8 (5) of the created annotations and 21 (12) of the queried were factual. The content of factual annotations often already exist on the internet, and thus the contents of the annotations should be acquired automatically from existing websites, such as Wikipedia or the official web page of the business.

Events: These targets (one created, two queried) included exhibitions and a festival. Due to their physical locations, these could have been categorized to indoor spaces and areas. However, the annotations were more related to the ephemeral event than its physical surroundings and were also relevant only for the period of the time of the event.

4.1.3 Categories of Created Annotations

Based on the content analysis of the created annotations, the following categories and motivations for using location-based annotations were found. The number of annotations falling into each category is presented in parentheses after the category name.

Factual annotations (6): These included factual information for example about the history and the nature of the location, or the opening hours and menus of the shops and restaurants they were attached to. Motivations for creating factual annotations consisted of sharing general knowledge for the common good, making an impression on others by showing one’s knowledge, promoting a place or object with personal value, and helping others seeking similar information. The content of factual annotations often already exist on the internet, and thus the contents of the annotations should be acquired automatically from existing websites, such as Wikipedia or the official web page of the business.

Reviews (24): This was the largest category, consisting of reviews and recommendations about the targets they were attached to, as well as tips and warnings (e.g. about a poisonous plant) related to the location. Reviews were made in an urban context for restaurants and shops, but there were also reviews related to tourist attractions, geocaching and nature. These reviews were occasionally complemented with factual information, such as relevant opening hours. Sometimes when writing a public review, participants left a separate message for their friends, including a more personal view of the experience. Reviews were created to help others seek positive (or to avoid bad) experiences, to promote a place or object with personal value, to warn others, or to remind others to behave according to effective norms and rules. Reviews of many targets already exist on other websites, and integration of the annotation system with the more popular sites would benefit and support the information needs of both location-based and web users.

Questions (4): This consisted of inquiries about the context of the creators, which were aimed to mainly benefit creators themselves, but also others needing similar information. There were questions aimed at obtaining factual information and recommendations about the target, as well as polls for gaining public opinion (e.g. the color that should be used for painting the walls of someone’s
house). Questions seemed to serve emotional, social, and pragmatic goals.

**Contextual invitations** (4): These were created to obtain company in one’s current location from acquaintances who may be passing by. They were targeted at a large but still selected group of acquaintances, and were valid only for the short period of time the creator spent in the location. As an example, one participant would have invited any close-by friends to join her for a lunch with a photo of the menu and a short text (see Figure 3).

**Logs** (7): These were “living” annotations that were created to gather content over a long period of time, to document events taking place at a location. They included both diaries for private and communal use, and guest books for public use. Logs were created to collect experiences from other visitors of an interesting location, and also as a way to participate in a group activities when one could not be present. For example, one participant could not participate in a regular jogging group session, but she still wanted to know the others’ times and to be able to challenge them for beating her results next time (see Figure 3).

**Mementos** (15): These were either private or shared representations of memories and experiences of the creator. Some of the memento annotations were made at the time of the event the annotation referred to, but there were also annotations that referred to events that took place many years ago. Private mementos were created to save descriptions of one’s experiences or feelings related to the location of the annotation. The mementos that were shared with others reflected motivations like showing the personal meaning of a place, increasing a sense of togetherness, and making an impression on others by telling them about an extraordinary experience related to the annotation location (e.g. having a party at an abandoned warehouse).

**Practical notes** (20): This formed the second largest category of annotations. It consisted of both short-term and permanent notes, kept either private or shared with a small group of close friends. Short-term notes consisted of for example reminders to do singular tasks and to-do lists related to a particular location. There were both notes created for oneself and notes made for friends and family members to inform them about one’s comings and goings and to coordinate joint activities. An example of a permanent note would be a navigational aid that one participant created for guests to find her home, including the parking space that should be used (see Figure 4).

Practical notes generally served pragmatic goals. They were created to manage one’s personal life (to ease one’s own memory load and cognitive burden) and events of communities important to participants.

**Affective notes** (15): These closely resembled SMS or emails, but their relation to the location they were added to was more important than for other communication media. The content of the notes was personal and they were targeted either to selected people or to the creator. Affective notes served more emotional goals than practical notes. Private ones were created to delight or motivate oneself, and the shared ones were either aimed at social interaction by prompting the recipient to call or meet, or reflected care for others in general. They were created to motivate or to amuse a friend, for instance, through spicing up or reshaping the environment. As an example, one note consisted of an anime character, Totoro, created by a participant to amuse her boyfriend at a bus stop they used daily (see Figure 4). All but one affective note had a defined lifetime, mostly in the order of months.

![Figure 3. (a) Contextual invitation: “Yummy, let’s have lunch!” (female, 26 yo, Tampere); (b) Log: “Here it starts - there and back” (female, 28 yo, Helsinki)](image)

4.2 Interaction with Annotations

4.2.1 Creating Annotations In Situ and Remotely

According to the diaries, fifty-two percent of the annotations would have been created right next to the target, signifying a clear need for being able to effortlessly create annotations to the user’s current location. However, there were still one-third of the annotations that were created more than 10 meters away from the target.

In line with this, participants in the interviews indicated the need to be able to select targets from one’s current surroundings, as well as from a longer distance. The importance of the latter option is emphasized by the need of location-based reminders, mostly created remotely before arriving at the location. For example, tasks that should be done at home often come to mind while not there. Typing or pointing from a map the address of the target could become tedious for regularly used locations, such as home. Hence, frequently annotated locations should have shortcuts in the user interface.

“If I have been in a location before and it would have left some imprint, I could mark the place for myself. Like my mother’s home; I’d often leave messages there, I could select ‘leave to my mother’s hallway’.” (female, 22 yo, Tampere)
Furthermore, the participants brought up that there is often no time to create an annotation in situ. This was reflected in participants’ experiences of filling in their diaries. For example, one participant wanted to create an annotation to help drivers avoid particularly heavy traffic congestion, but she was only able to make the diary entry after stopping for a cup of coffee. This would have also been the case for a real annotation. Thus, an option to attach annotations to recently visited locations would have been appreciated.

### 4.2.2 Limiting Access to the Annotations

The need for an option to limit the visibility of the annotations was emphasized in all the data gathered in this study. Across the diaries, 42% of the created annotations would have been shared with anyone, 24% with all friends, 24% with certain people, and 10% would have been kept private. Furthermore, the importance of the issue also came up many times in the interviews. In addition to direct comments, the participants often discussed the value of an annotation being related to their friends seeing it.

> “I would also like to entice my friends to come to this place.” (female, 28 yo, Helsinki)

Participants were also able to decide about editing rights for each annotation. For half of the annotations, participants did not allow editing rights for others. The rest was divided evenly between ones that other users could freely edit and ones that would require creator’s permission. Mementos were typically set to remain unchanged, while factual information could have been edited, reflecting the nature of both annotation categories. Naturally, logs were also set to be editable by others to enable collecting experiences from several people.

### 4.2.3 Viewing Annotations

Whether the users of an annotation system want information from friends or the public seemed to depend on the annotation category. In attitudinal annotations, such as reviews, knowing the background of the creator helped the user in interpreting the message.

In addition to the information about the creator, seeing a public opinion or rating about the annotations would help the user to select the most appropriate and useful annotation from the available ones. For example, enabling users to rate the annotations with “+” and “−” would help in emphasizing good quality annotations from the poorer ones. In busy, everyday life, it is also very important that the offered information is real-time information, whenever appropriate (e.g. when looking for a restaurant, the ability to see which places are currently open). With regards to a personal message left for a friend, a notification about its delivery was desired.

> “In case of a personal annotation for a friend, you’d like to know when it’s viewed. When you’re leaving it, you could select from which actions you want to be notified.” (female, 22 yo, Tampere)

However, as an automatic function this would violate the recipient’s privacy in terms of their location disclosure, so methods for controlling delivery notifications should be considered carefully.

### 4.2.4 Notifications about Nearby Annotations

The need for location-based reminders became apparent via the participants’ diaries. When creating a reminder, the user seldom is in the location where they want the reminding to occur.

> “It would be nice to receive ‘Hey, now that you’re home, remember to pack these things’ written earlier before arriving home.” (female, 28 yo, Helsinki)

The participants also noted in the interviews that annotations like reminders may have several meaningful locations, and that interaction with one instance should reflect all of them. It was suggested that the user could tag certain places, such as their favorite groceries, and at home they could use this tag to place a reminder on all of these groceries.

In the interviews, participants also expressed strong concerns about whether their friends would find the annotations targeted at them. They therefore wished for their friends to be notified when arriving at the location. Participants’ attitudes toward receiving such notifications about annotations were dependent on the content of the annotation. Messages from friends, however, were generally seen so important, and interesting that notifications about these would be accepted.

> “Presents and positive surprises I would accept automatically with notification.” (female, 26 yo, Tampere)

The optimal radius of notifications depended on the context. In the home town, the notification should arrive close to the annotated target to ensure the relevancy of the annotation. While driving within the countryside, for example, the area of notification should cover the main roads to support finding the annotations.

Notifications were also desired about friends’ activities in general.

> “[I would like to be notified] if my friend created a tag within 10 km – if it was close and interesting, I would go there too.” (female, 28 yo, Tampere)

### 4.2.5 Lifetime of Annotations

Several different criteria were identified for determining the desired lifetime of an annotation, depending on the purpose of the annotation. Reviews, questions, logs, and mementos were often set as permanent. For affective notes, it was usually enough that the recipient saw it once. In cases where the recipient might not receive the message in time, some annotations would become outdated, so a date for automatic expiration would also be needed. This is especially relevant for to-do annotations and contextual invitations, for which participants hoped for option for manual deletion. For these annotations, the author would judge as events evolve when the annotation would become outdated.

> “It could exist until it is viewed or read a certain number of times. In case of leaving greetings, there’s no point that it would stay after it has once reached the recipient.” (female, 26 yo, Tampere)

### 4.2.6 Social Acceptability in Creation Phase

In general, creating an annotation with a mobile phone was seen to resemble normal mobile use, both in good and bad. For example, creating an annotation by pointing at an object with the camera phone and typing with the mobile is something already done, so this kind of interaction was not viewed as making the
user look any different from one who takes photos and writes text messages. However, it may feel uncomfortable pointing at mundane objects with a camera phone, and users may start to become self-conscious about others possibly wondering why they are taking photos of such objects. For example, one of the participants wanted to add an annotation to the candy shelves of the grocery store she uses and described how she felt uncomfortable and almost embarrassed when taking photos of the shelves for the diary.

5. DISCUSSION
5.1 Methodological Considerations
In retrospect, our research approach and the diary method also had inherent limitations that might have affected participants’ diary entries and thus the reliability of the results.

First, participants were selected based on their expected activity in creating annotations. Focusing on active and extroverted kind of participants did in all likelihood affect the amount of annotations created, and most probably also the motivations behind creating them. Also, all participants were Finnish, which might have created cultural bias in the results. These limitations were recognized in planning the study but were considered justifiable as our goals were to explore the various types of annotations early adopters would create with such a service – not to study the topic considering entire populations.

Secondly, studying the possible use of an imaginary technology that does not yet exist is unquestionably a challenging task. Therefore, to ensure that the participants really understand what such services could enable we decided to use stimuli that elucidated possible uses of such technology. Although this was considered necessary for gaining relevant and insightful data from the study, we must admit that the introductions to the topic and tasks given to the participants during the diary period most probably affected the content of the created annotations. In general, if people are inquired about needs for a novel and hard-to-comprehend technology, concrete examples are needed.

Earlier diary studies have shown that having a long period of reporting requires external motivating and inspiration. Furthermore, the possible “priming effect” that the stimuli had on the participants most probably weakened over the almost two-week diary period. Also, none of the categories reported in results consisted mainly of annotations created due to any of the tasks. For example, replies to task 1 about creating an annotation related to one’s daily routine were spread over four of the categories: factual annotations, logs, practical notes, and affective notes.

Third, with a research approach focusing on non-functional concepts, we could not consider real annotations created in actual interaction. Although providing tasks as stimuli during the diary period, the annotations reported could have been limited on people’s earlier experiences of interacting with existing location-based services or mobile information services in general. Also, such an imaginary system as used here is essentially a one-way annotation system. The feedback from other participants would be an important motivator for creating annotations in a real system. Even just the knowledge that one’s friends will see the annotation forms a large part of motivation of using a real annotation system. In our setting, the participants had to imagine creating notes to their friends and it has affected the results somewhat. To study the effect of social interaction would unquestionably require a pilot study with a fully functional service.

5.2 Reflections on the Results and Previous Research
We identified eight categories of annotations made in the diaries: factual annotations, reviews, questions, contextual invitations, logs, mementos, practical notes and affective notes. Based on these, both pragmatic and emotional goals seemed to be important motivators for creating location-based annotations in everyday life.

Most current mobile MR annotation services, such as Junaio, focus on playful entertainment purposes. Considerable amount of the annotations in our study, however, were related to everyday practical needs, such as reminders to reduce memory burden, or reviews to share a personal point of view of a commercial service. Some of these still relied heavily on the means of MR (e.g. an annotation visually pointing out parking slots for guests, and navigation aid arrows for those coming to one participant’s home).

Location-based annotations and messages have been categorized in previous studies as well [3,9,15]. As these previous categorizations are based on the use of existing systems focused on certain annotation types, our study’s recognized categories are not identical with them, although there are similarities.

In their public annotation study, Burrell et al. [3] identified similar categories to our study’s factual annotations, reviews, and questions. These categories also mostly consisted of public annotations in our study. Reviews (opinions/advice) was a popular annotation category in both studies, but factual annotations was the largest category for Burrell et al. [3] while one of the smaller ones in our study. On one hand, our study’s setting was also open for more personal content by enabling visibility limitations on annotations, resulting in an abundance of imaginative content intended to be shared among one’s friends or stored for oneself. On the other hand, the motivation of creating public annotations comes largely from other users seeing them, which could not be simulated well in this study.

An earlier study by Jung et al. [9] identified categories for personal location-based messages. Categories resembling our study’s shared practical notes and affective notes emerged from their data. Rantanen et al. [17], in turn, saw use of contextual invitations in their study. However, unique to our study’s data was the MR annotations, where participants envisioned navigational aids floating in the air or attached to building walls, and cartoon characters welcoming them into their regular bus stop (for example). Our data also consisted of quite many mementos, which likely came from wide options for media types that could be included in the annotation. The required features would be tedious to implement, but by using the diary method we were able to collect requirements that will help the designers of future systems to implement these features in a way that they will benefit users most.

5.3 Design Implications
Based on the findings of this study, we concluded the following design implications for location-based annotation systems. While describing the design implications, we discuss how the issues...
have been considered in earlier research. We also discuss the implications in the case of MR annotation systems.

5.3.1 Support Flexible Selection of the Target of the Annotation
Users have more versatile needs for annotating than merely annotating a certain location. In our study, areas, indoor spaces, individual objects, and ephemeral events were also annotated. The last two were also identified in the study of GeoNotes, where items and events were discussed by using the system [15]. Annotations not directly related to location have previously been viewed as a failure of the design [2,17], but our study’s results suggest that the optimal solution should provide options for defining the variety of target types required to support users’ everyday lives. An MR annotation service could provide methods for referencing to real world quite precisely, like selecting parts of buildings as targets.

5.3.2 Support Creating Annotations from a Distance
Our results suggest that flexible options for defining the location of annotations would be needed. Location-based reminders would have been created when not at the location the reminding was supposed to be given. This is consistent with earlier studies of location-based reminders [11,19]. An annotation service with MR views could take advantage of, for example, satellite or aerial images about the location as suggested in [21].

5.3.3 Provide an Option for Sharing Annotations with Selected People
Some researchers have made a deliberate choice of allowing only public notes in their location-based annotation system in an attempt to provide more content for all users to browse [16,17]. In contrast, our study’s results strongly point out that in many use cases annotations are intended only for certain people and will most likely not be created at all if only public annotations are allowed. With a wide variety of audio-visual content, our study’s participants wanted to for example surprise, amuse, and motivate their friends. This suggests that an annotation service with flexible sharing options would provide special value for users. The visually rich nature of the annotations created in our study underlines the possibilities of MR visualizations in this area.

5.3.4 Support Collective and Living Annotations
Several annotations created in our study were shared with an attitude that they could be freely edited and enriched by the group of users that the annotations were shared with. For example, annotations that would act as public guest books would gather content from any visitor of a location, providing viewpoints outside the author’s normal circle of friends. Factual information could also be gathered from anyone who has good knowledge of the subject. The information would thus remain more up-to-date and relevant for future visitors of the location, as discussed in [14]. In addition to public annotations, for example shared to-do lists would benefit from group members being able to acknowledge the tasks and mark them as completed.

5.3.5 Provide an Option for Notifying the Users about Nearby Annotation
Our study’s participants expressed strong concerns about their friends finding the annotations targeted at them. This problem has also been identified in previous studies (see [17]). In addition, the core motivation of creating personal location-based reminders is to be notified about an issue one might not otherwise remember [11,19]. Hence, for annotations created for oneself or other selected people, a notification functionality should be provided. However, to discourage spam-like behavior, creation of public annotations notifying all users should not be allowed.

6. CONCLUSIONS
We conducted a user study to understand the user needs for location-based annotation services in the broad context of everyday life. Our participants kept a diary of the annotations they would create if an ideal system was available. Although the annotations were fictional, the diary entries suggest that the annotations were carefully considered by the participants. The main contribution of this study is the new insight regarding users’ needs for location-based annotation systems for their daily tasks and for communication with their friends and family. Furthermore, based on these findings, we presented design implications for such services. To support the versatile use of annotations seen in our study, flexible options are needed for selecting the target of the annotation, for remote annotating and for setting the visibility of the annotations. Moreover, a notification feature is required to support personal use, as well as private messaging among family and friends. Finally, an optimal system should also support collective and living annotations editable by several contributors over time.

7. ACKNOWLEDGMENTS
We would like to thank Else Lagerstam (TUT) for her help in organizing the Tampere interview sessions. We are also grateful for Brenda Castro and David Murphy (NRC) for their help in planning the inspirational parts of the study. Furthermore, we thank Pirita Ihmäki and Professor Kaisa Viinänen-Vainio-Mattila (TUT) for their input in the planning phase. Lastly, we express our deepest gratitude to our creative and dedicated study participants.

8. REFERENCES


