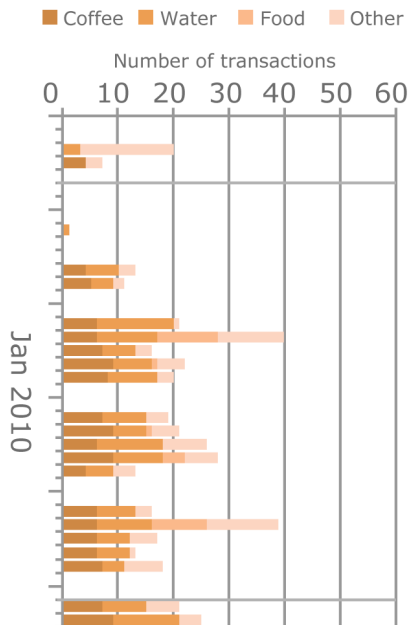




Figure 1: The Barkeeper is a marker-based payment system for tracking the coffee consumption of an HCI lab.

Figure 2: Visualizing the lab's consumption of coffee, water, food and other beverages using the Barkeeper's data.



The Barkeeper Experience – Living with a Virtual Bartender

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Abstract

Many aspects of our daily lives are supported by technology. The main criterion for replacing established processes by technical solutions is usually improved efficiency regarding time or energy. In this paper, we present the design and evolution of a digital tracking system for consumption and payment of beverages – the Barkeeper. Its design was not primarily guided by efficiency, but practicality in day-to-day use. We, an HCI group of 20 people, have lived with our Barkeeper for 3 years now. In this trusted environment, we collected extensive usage (and beverage consumption) data, making this one of the larger field deployments of UbiComp technology. We present the Barkeeper, its users' views on it, some insights gained by daily usage and identify important design rationales and future directions for the development of such systems.

Author Keywords

coffee, visual markers, ubicomp, payment system

ACM Classification Keywords

H.1.2. Models and Principles: User/Machine Systems [Human Factors]; H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

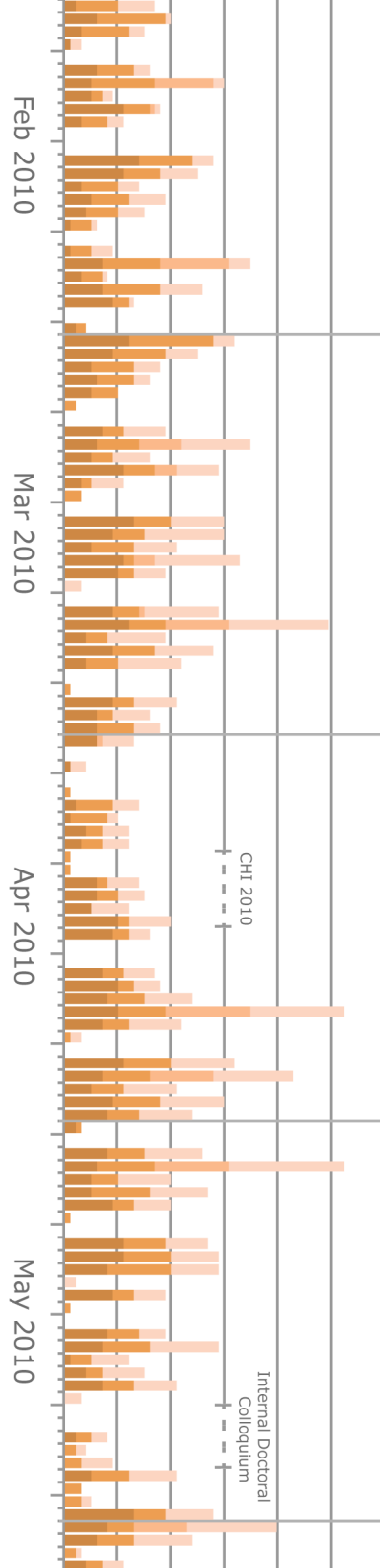
General Terms

Human Factors, Experimentation

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CHI'13, April 27 – May 2, 2013, Paris, France.

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Introduction

Caffeine is an essential part of every (good) computer science lab as a number of studies proved the positive effect of caffeine on performance [4, 7, 8, 13]. The most common way of getting it into the bloodstream is drinking coffee. In order to track our consumption of caffeinated (and other) drinks and to share their cost we devised an interactive system called *Barkeeper*. Since computer scientists are known for being social introverts [14] and secretaries are usually focused on keeping a balanced budget, we considered and partially tested a number of (technology-mediated) solutions to track our coffee consumption over the last years: tally lists, mobile apps (such as [1]), desktop/web applications, RFID [10, 11], NFC [12], sensing cups [3] and visual marker-based systems (such as [9] or [15]).

For sharing costs among colleagues, we first used a simple paper-based tally list for several years. This approach caused several problems: (a) With the growth of the group and the increasing fluctuation (people joining or leaving the group), the approach did not scale well. (b) It regularly caused a large administrative overhead for calculating the individual spending. (c) It was hard to keep track of one's own expenses and possible errors due to inattentive or malicious colleagues (using wrong rows or columns in the list). (d) Each user had to fully trust the mathematical abilities of the secretary.

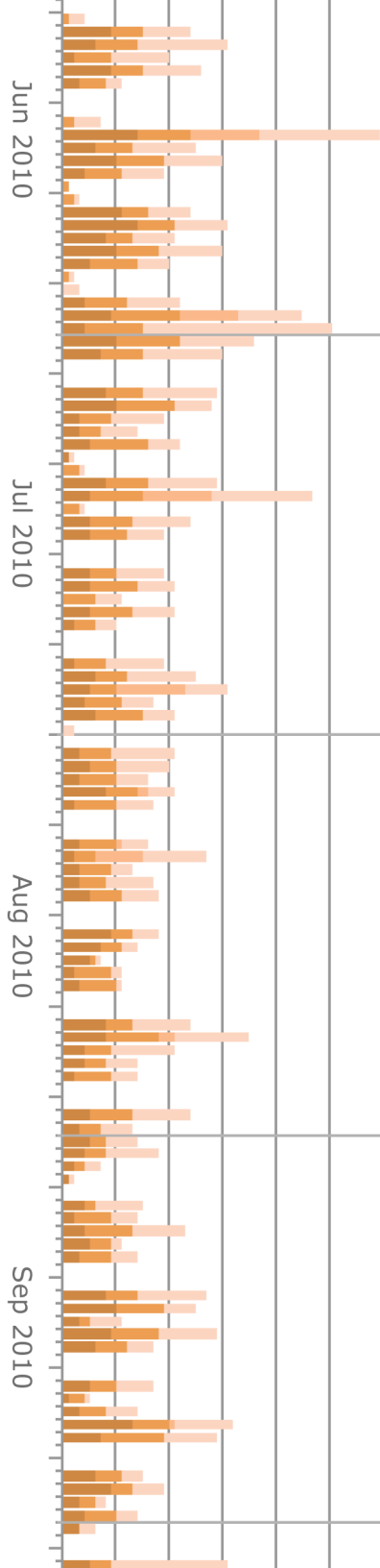
In order to solve these problems, we switched to a new technology-driven approach. Our initial system was based on a client-server architecture that followed Kent Beck's paradigm of simplicity [2] to build "the simplest thing that could possibly work". Besides this, we had to design an affordable solution as the university budget does not provide funds for "coffee expense tracking".

We chose visual markers (QR codes) for interacting with the system. This decision was based on the following assumptions: QR codes are (i) cheap, (ii) robust, (iii) suited to make the system highly scalable (e.g. adding people), (iv) easy to use and (v) they can handle coffee being spilled over them [6]. Together with a 3€ webcam donated by one of the authors and an old computer that was about to be thrown away, the system was complete. The webcam was installed at the wall of the kitchen such that it permanently focuses a certain marked "reading area", where all the interaction with the system takes place.

When a thirsty person comes to the lab kitchen, she looks for her own tag in a box with "user tags" and the tag showing the QR code for coffee in a box with "product tags". She then places both tags in the reading area one after the other while receiving auditory feedback. She also grabs a cup¹ and launches the coffee brewing process. A simple optimization of this process was soon discovered: Starting the brewing process before searching and scanning the tags allowed parallelizing these two process steps.

In this paper, we present the results from 3 years of everyday interaction with this system in our lab. To our knowledge, there is no work in which visual markers were evaluated over such a long period of time in a real-world deployment. We discuss the advantages and disadvantages of using QR codes and report insights from different user perspectives (e.g. administration, users). This includes highly personalized strategies of

¹ The *Barkeeper* system does not provide any reminder for placing a cup under the coffee dispenser yet for the absent minded professors and sleepy students.



the payment system (e.g. different ways to scan and store visual markers) and effects on social interaction within the lab. Besides that, the huge amount of collected expense data makes it possible to reason about interesting privacy attitudes and user behavior in a financially backed system (e.g. are people comfortable with debts on their account?).

The Barkeeper System

The Barkeeper started as a small server application with a web frontend. It had database tables for items, users and expenses generated by buying items. The new idea is that expenses are captured directly when taking a drink and not after the long way back to the office computer. Thus, to register a purchase, users now place tags with printed QR codes in the reading area below the wall-mounted camera (see figure 1).

Server and Hardware

The system is running on a simple WAMPP server on a thin client: 1 GHz, 512 MB RAM, 40 GB HDD with a camera (640x480, 30 fps) connected to it. A Java + JavaMF application accesses the camera image and processes it using the ZXing² library.

Scanning the Tags

There is a QR code tag for each user and product. A tag contains a textual category id and the id of the respective data (e.g. "U_23" or "P_12") encrypted using the QR code specification. The Java application waits for a user to scan two tags consecutively (one product and one user tag) or resets itself if only one tag was scanned within ten seconds. Once both types of tags have been scanned, a buying request is sent via HTTP

to the backend server. If multiple tags of the same category are scanned, the last one overwrites previous scans. Simple auditory feedback indicates whether a scanning action was successful or not. To save time, each user can print combi-tags that combine their user id and a product id within the same size as normal tags. These individual combi-tags are only printed as needed and for an individual's favorite beverages, which avoids a rapidly growing number of printed tags.

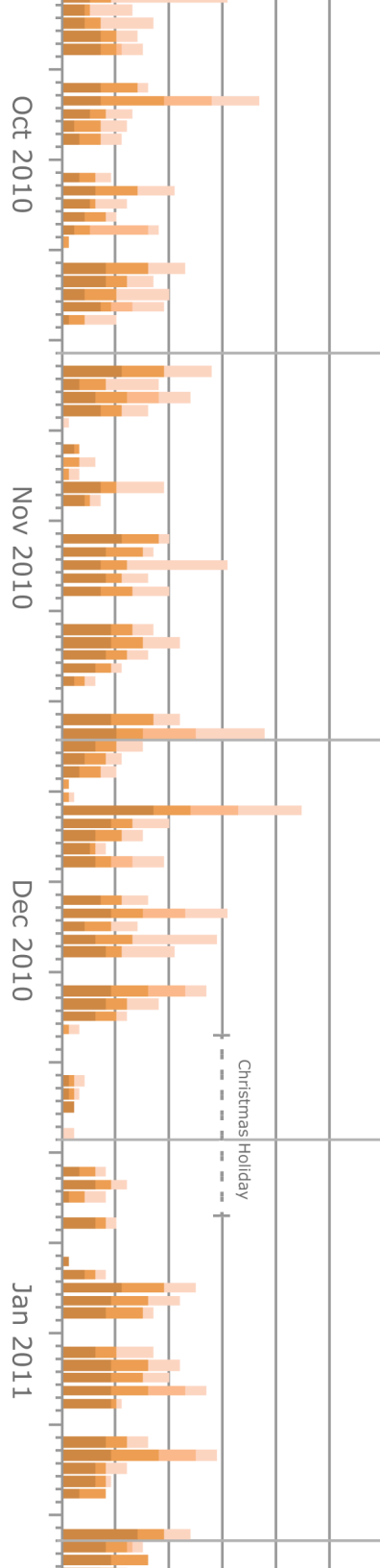
Feedback

There is no visual feedback for the scanning system in the kitchen due to the lack of a suitable monitor or display and other kitchen-related reasons such as moisture or dirt. Instead, we chose auditory feedback with two different auditory icons. A positive confirmation is played for scans and successful purchases and a negative one is played when the system resets due to the time constraint or if the submission of a purchase to the server fails. As additional feedback, the user also receives an email after every purchase, confirming the successful payment and stating the new account balance right in the subject of the email.

The Evolution of the System

Starting with only its basic functionality, the Barkeeper evolved quickly as colleagues and guests made suggestions on how to enhance the system. For example, the combi-tags were implemented after the first few days of using the system. Since the system has a virtual account balance for each user, we also implemented a transaction feature that allows everybody in the group to transfer money between their virtual accounts. For example, if two colleagues went to lunch together and one of them paid for both, the money can afterwards be paid back via the Barkeeper.

² <http://code.google.com/p/zxing/>, last accessed: Dec. 19, 2012



Another change request was an adjustment of the sound effects: the original horn-like sounds were replaced with natural and therefore less annoying ones. Successful scanning is now indicated by the call of a cuckoo and an error by the cark of a crow. While these new sounds are distinct enough as signals for the actual user, they quickly blend into the ambient soundscape of the surrounding office environment. As a subtle side effect, one user reported that he now is irritated when hearing a crow in nature, wondering what went wrong.

A mechanism that evolved during longer use was the introduction of group tags: several people who frequently meet in the lab and whose consumption during these meetings is covered by different funds, received tags with special aliases. In addition, a general guest tag was introduced with the name of a famous drinker whose drinks are paid for by the entire lab.

But the Barkeeper system is not limited to scanning QR codes. Users can log on to an online frontend to check their balance, print combi-tags, transfer money, and change several settings. Furthermore, an Android app was created that allows users to purchase drinks, see their balance and make financial transactions. The complete functional range of the system as of today is far beyond what would fit into this paper (e.g. restaurant ratings, administrative functions).

Security and Social Implications

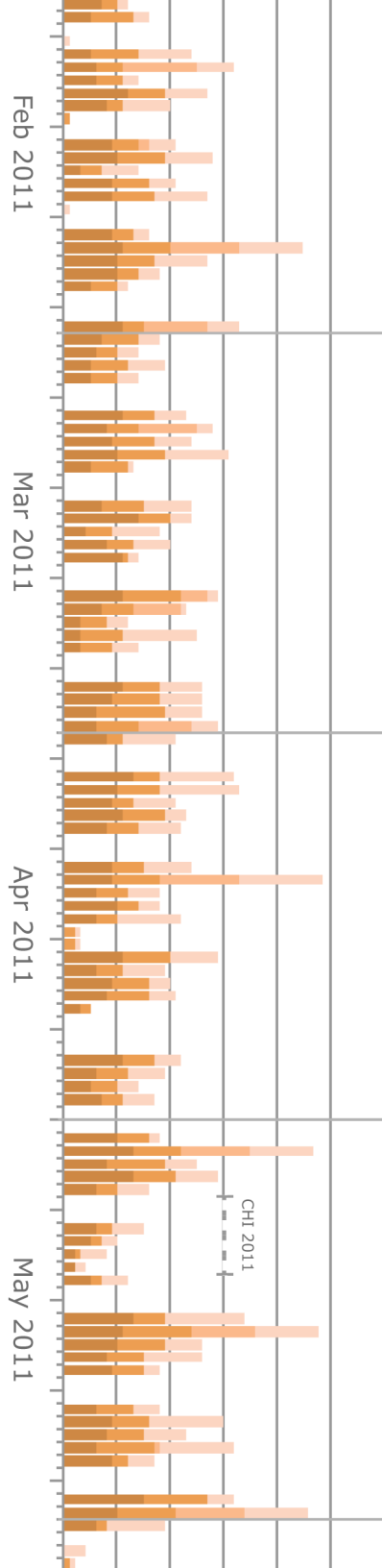
From different perspectives onto the system, various advantages can be identified: From a technical point of view, we managed to implement a low-to-no-cost system (see *Server and Hardware*). Running costs are also low because the paper tags can be cheaply printed and the server consumes only little power.

Both security and privacy improved with using the Barkeeper compared to the tally list. Tally marks were often made in wrong rows or columns, leading to false purchases. On the contrary the QR codes can easily be taken away or hidden to achieve higher security. Although the system is still not perfectly secure: Once a person gets hold of the tag or the specific user id, one can simply copy or reproduce the tag to impersonate the original owner. However, through email notifications, misuse of a tag is easily detected.

Concerning privacy, others cannot see the purchases previously made as it was the case with the tally marks. In addition, all purchase information from the tally list was lost as soon as bills were paid and the list was replaced by an empty one. Today's system keeps track of all purchases without ever deleting them.

From a social perspective, the daily use of the Barkeeper influences group behavior in significant ways. Being used for interpersonal money transfer, the Barkeeper has established a new verb in communication between the lab members. "You can just barkeeper that to me" has become a phrase commonly used.

The data information of the Barkeeper is also used as a means of social pressure to support positive payment behavior. Every 30 days, the lab employee with the highest debt is announced in an email as being the one to get the milk from the supermarket for the next 30 days. The "best man" having the highest credit is also announced in this email but without further benefits. These mechanisms caused the group's cash box to change from being constantly empty to being well filled within days.



Different Views on the Barkeeper

In this section, we present some of the unique strategies that a heterogeneous group of users developed over the past years. While professors and colleagues from different floors of the building come to the kitchen to purchase drinks the secretaries have to keep track of costs and take care of keeping stock up in the kitchen. In order to understand their unique usage strategies, we performed a semi-structured in-depth interview with the current secretary about her view on the system. We also acquired basic information from her predecessor. Finally, we conducted a survey with the broad user base (students and internal as well as external colleagues) asking them about their interaction with the Barkeeper.

Administrative Staff

While one secretary witnessed the switch from the tally list (used it for 10 months) to the Barkeeper (used it for 9 months) the current secretary has been using the Barkeeper for 26 months. Both learned how to use it on the fly: Whenever a question arose, the main developer gave them a brief introduction. One secretary stated that the learning time was “ridiculously short”.

The old tally list required the secretary to take it down, calculate all outstanding amounts and put a new list up every week. The only task now is to accept the money from users, put it in the physical cashbox and add the paid amount to the respective Barkeeper account using the administration interface. As one secretary stated, the most complex thing for her while working with the Barkeeper “is to put the cash into the cashbox”. Adding the paid amount itself only takes a few seconds.

User Perspective

To get subjective insights on the everyday usage of the Barkeeper, we conducted a questionnaire filled out by 21 current and former users of the Barkeeper (six female, 31 years on average). 13 participants are currently working at the lab, one participant is an external Ph.D. student and six are former employees.

The first part of the questionnaire contained questions about the usage of the system. Fourteen percent of the participants stated that they used the system daily, 48% even multiple times a day. Although providing a range of functions, paying for drinks is used most frequently. The preferred interface for buying drinks is the tag-based payment, which is used frequently by the majority of the participants (81%). Nearly all participants (95%) hardly ever use the web interface and only two participants (10%) use the mobile app.

Several styles of tag usage for payment have emerged: Most users search for both – user tag and product tag – first and then place them under the camera (38%) consecutively. An alternative method is to find one tag, place it under the camera and use the scanning time for finding the second tag (19%). One user notes: “*I always kind of conceived it as a game. Do I succeed in finding the second tag before the purchase would fail?*”

There are also several ways of speeding up the payment process. Seven participants (33%) use at least one combi-tag. Five participants (24%) reported own methods such as gluing a small flag to the name tag to reduce search time or changing the location of the tag (e.g. sticking it onto the kitchen cabinet or storing it at one’s office desk).

Jun 2011

Jul 2011

Aug 2011

Sep 2011

Chair Meeting (biweekly)

Inte

One participant reports on a strategy against tag loss: *"For some time, I had a stack of combi-tags for coffee in my office and in the kitchen because I lost them so often."* The Barkeeper can even act as a decision helper: *"Sometimes, the first drink tag I see influences my choice of product."*

The change from a tally-list-based payment method to the Barkeeper also entailed a new form of billing: Nine participants perceive the Barkeeper as a prepaid system while seven use it like an account with credit. The remaining five participants understand it as *"a prepaid system with nice credit possibilities"*, as one user put it. The most frequently used time for increasing one's balance is to deposit money at a certain threshold (67%), followed by doing so right before the "milk fetcher" deadline (24%). One participant stated to recharge in irregular time intervals.

In general, the participants are satisfied with the Barkeeper. The tag-based payment is rated as easy-to-use (mode=4 on a five-point Likert scale ranging from 1=strongly disagree to 5=strongly agree), stable and robust (mode=4) as well as fast (mode=4) (see figure 3). Twelve participants who had experienced the old system rated the tag-based payment as easier (mode=4) and less error-prone (mode=5) than the list-based payment. Half of them think that paying with tags is faster (mode=4) (see figure 4). 18 participants (86%) consider the auditory feedback as funny; however, seven (33%) have suggestions for alternative sounds, three participants would like to have individual sound themes. Another three would prefer synthetic voice feedback and one would like "something more intuitive".

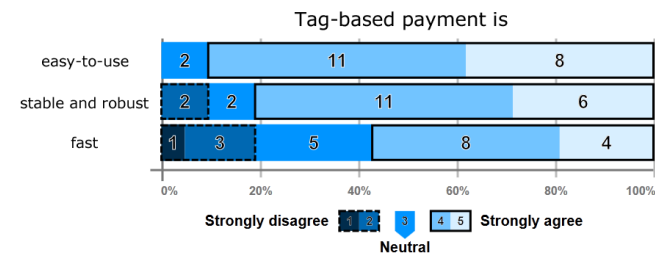


Figure 3: Rating of the tag-based payment.

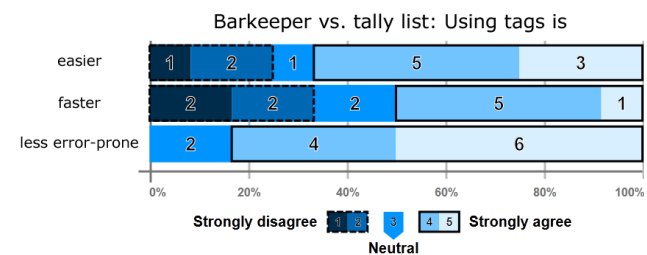


Figure 4: Comparison between tally list and the barkeeper.

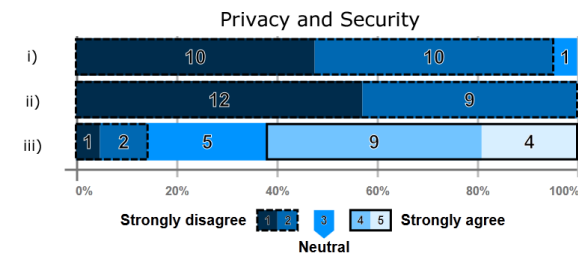
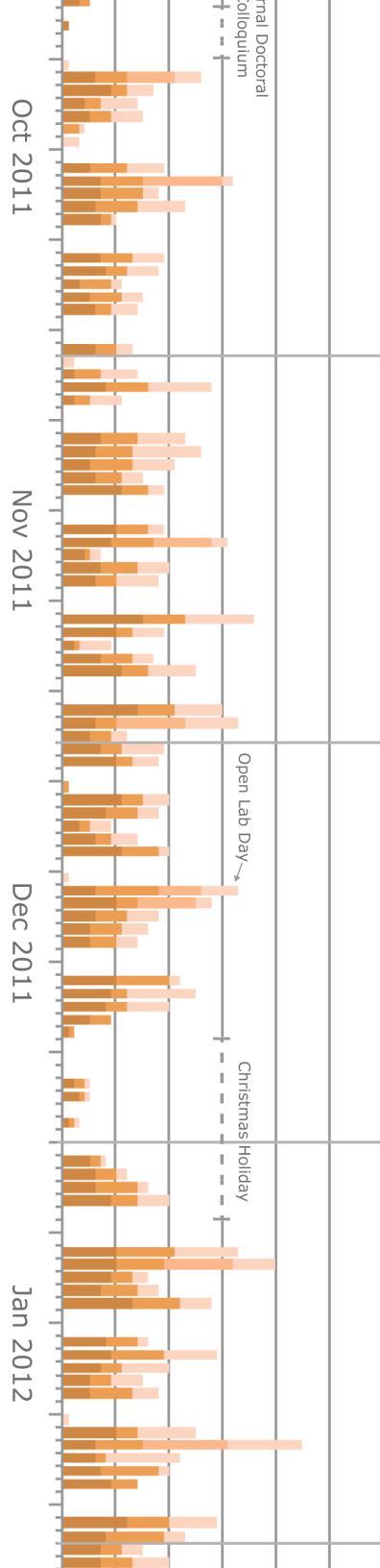


Figure 5: Rating of privacy and security aspects: i) I am afraid that my tags might be misused by others. ii) The open access to the tags encourages intentional misuse. iii) The monthly public announcement of the user with the highest debt is fair



Most participants are not afraid that their tags might be misused by colleagues (mode=1.5) and all agree that the open access to the tags in the kitchen do not encourage intentional abuse (mode=1). Asked if the monthly public announcement of the user with the highest debt was fair, 19% strongly agreed, 43% agreed, 24% were neutral and 9% disagreed and 5% strongly disagreed (mode=4) (see figure 5).

Almost all participants think that the system will continue to be used after its creator will graduate. Only one participant is skeptical: *"At least not for long! Once it breaks no one will feel responsible to fix it, [...]. The remains of the broken Barkeeper will stay in the kitchen, however, as a perpetual reminder for the volatility of all worldly things."* Eight participants stated that people in their personal environment (beyond the actual users) know about the Barkeeper. Half of the participants adapted the verb "to barkeeper" (*transfer money to someone else*) to their vocabulary. Seven participants have thought about extending the system themselves or told the developers about their ideas. The ideas include integrating a smart watch, a fingerprint reader for user identification and automatic recognition of drinks by scanning the shape of the bottles.

Only a few people speed up interaction (e.g. using combi-tags). Besides the initial barrier (printing these tags on their own) there seem to be other different reasons for that. Participants apparently differentiate between some kind of quick drink fetching and taking a larger break from work. For those who go to the kitchen taking a break the whole process is not time-critical hence speeding up the buying process is not necessary for them. Although we did not find any significant differences data in our questionnaire results this also

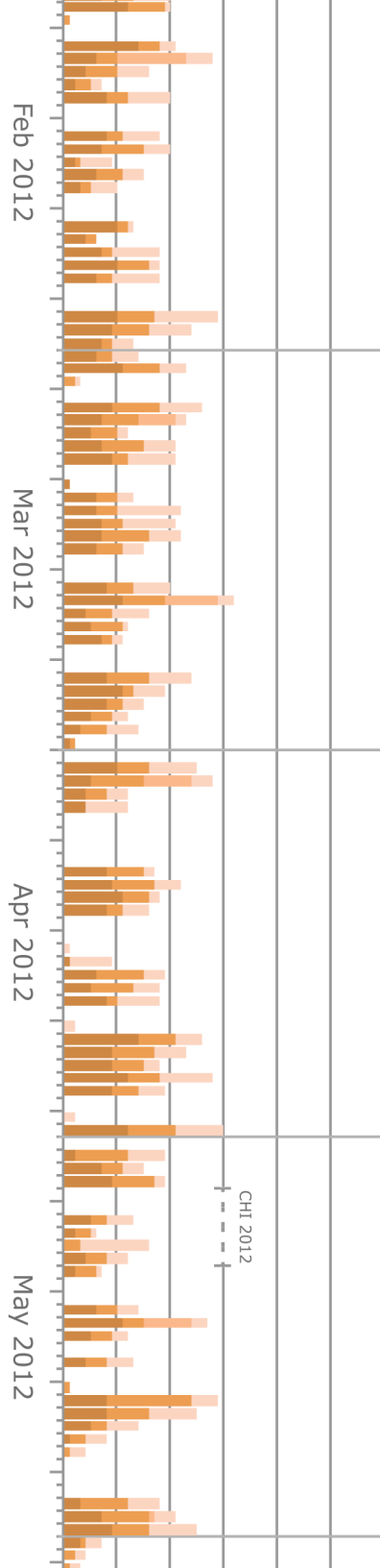
seem to correlate with the two different floors people are working on with users from the barkeeper floor speeding up the process more often. People possess less combi-tags as they have to come up to three floors to get their drinks and mostly seem to do this for larger breaks. Colleagues working on the upper floor have the kitchen right next to their offices and do their purchases in between, leading to more combi-tag usage.

Living with the Barkeeper

Analytical results on the long-term use have been obtained in two main ways: a quantitative analysis of usability, and insights on usage behavior or special events. To assess the usability of the different booking methods (tags, app, web and paper), we first measured average interaction times with each of them and made several observations. The Barkeeper itself also collected a lot of quantitative valuable data about usage behavior (see figure 2).

Methodology

We measured the average interaction times with single tags, the web frontend and the tally list of 12 users. The Android app was excluded due to underutilization. Measurements were done with a stopwatch during daily routine to include influences like the changing order of tags in the collecting box. Hence the measured times include searching the right tags as well as successful scanning. The interaction with the tally list includes the search for the pen as well as for the right row and column. Possible personal strategies were recorded.



Results

The average interaction time with the tally list was the fastest ($m=7s$; $sd=2s$), followed by the web frontend ($m=15s$; $sd=3s$). The interaction time with the single tags was the slowest ($m=22s$; $sd=7s$). Only four participants used combi-tags, however it was faster than the tally list ($m=6s$; $sd=1s$). While we do not have quantitative information on compliance (people paying for their drinks properly) the secretaries hint at the fact that the Barkeeper may improve general compliance more than it improves time-efficiency.

The data of the Barkeeper database is in line with the results of the qualitative analysis. Until December 2012, 11,941 QR-based transactions were performed, while only 1,188 web-based transactions (10%) were logged and the mobile app had been used 76 times (0,6%) only. Since its introduction, the Barkeeper was used on 96 % of all working days (excluding public holidays) with an average of 20 transactions per day. During this time, a total of 14,878€ have been transferred.

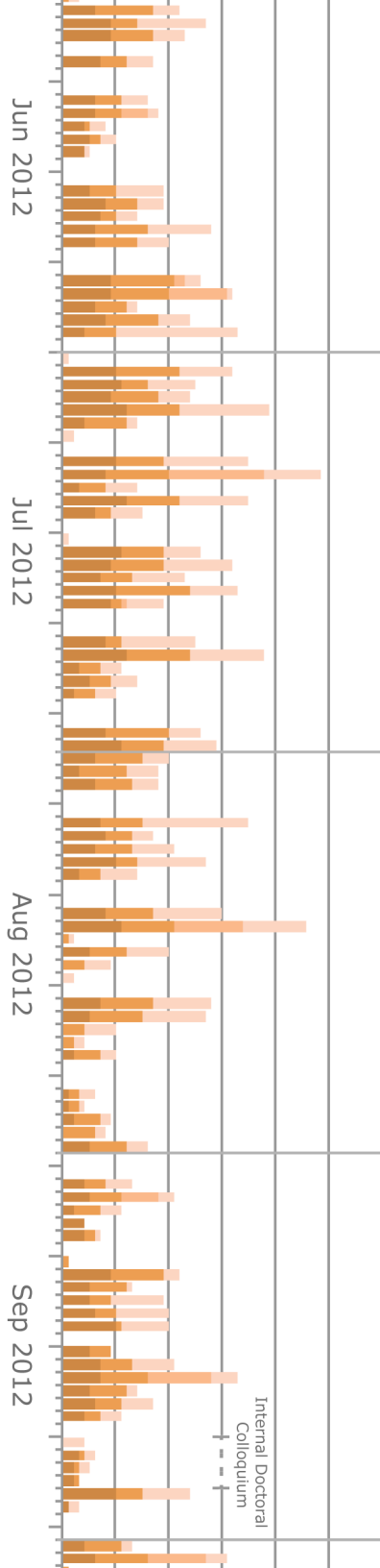
The data also allows easy identification of patterns such as limited use on weekends, during CHI dates and public holidays (see Figure 2). As an example, the eruption of the Eyjafjallajökull during CHI 2010, which resulted in an extended absence period for a significant part of the group, is clearly visible in the usage data. Further analysis revealed that coffee is the most consumed drink in our lab. 4,918 items (cups and mugs) have been sold during the three years the Barkeeper is installed. Water scores second with 4,356 units. Most coffee is consumed on Mondays and daily peaks can be found from 09:00 to 10:00 in the morning and from 01:00 to 02:00 in the afternoon right after lunch.

Looking at the payment data reveals that the overall payment moral is well balanced. Only 48% of the logged transactions were performed by users with a negative balance, while 52% of all transactions were performed with a positive one. Overall, the maximum debt, which was ever recorded, was -83.53 EUR, while the maximum positive credit was 104.46 EUR. The same user having the maximum debt bought 90% of items having a negative balance. In contrast, other users performed over 95% of the transaction with a positive running total. This shows that payment behavior is very individual and backs the result of the questionnaire: some users perceive the Barkeeper as a pre-paid system, while others think it is postpaid.

Discussion

Developing the Barkeeper had some initial advantages mainly for the secretaries, while it produced measurable disadvantages for its users. The tag scanning time is almost three times longer compared to adding a tally mark, which meant a performance drop in average for all other colleagues. Why is the system still up and running after 3 years? Is it because of the gained control over expenses and the fact that nearly no erroneous purchases happen anymore or is it just because the users love to prove their geekiness with it?

For the secretaries, the system is a clear win in terms of time and effort. While a transition to new software usually presents a hurdle to users (e.g. transition to Windows 8) [5], the application was quickly adopted in our case. We attribute this to our extremely flexible development approach that closely incorporated the final users and provided them with a nearly immediate development cycle that took mostly about 24 hours.



The standard users not only accepted the transition to the new system but most of them also chose to use the QR codes despite the higher interaction times compared to the tally list. Some users developed own strategies to speed up the process of buying with own methods (e.g. marking of tags). Others even improved their coordinative and motor skills (brewing coffee with one hand while simultaneously placing the tags with the other). However, most users stick to the simplest purchase procedure using two single tags consecutively although they are aware of the possibilities to speed up. We assume that it is simply because scanning the tags can be easily integrated in the process of getting a drink (including chit-chat) so that people do not mind that it takes longer. Also the playfulness of the interaction fits well with the mood of having a break.

One of the major differences to most common usage of visual markers is that users take the visual marker to a fixed camera instead of actively taking a picture *with* a hand-held camera. Based on our results, we suggest that systems that work in this way can be much more usable and accepted by users, since all the effort spent on focusing the picture on the marker is removed.

The stability and usability of the system also seems to create a certain kind of trust amongst users: Tags are not hidden; personal finance transactions are performed; the overall system is not put into question. We argue that the high transparency of transactions through immediate email feedback and thus a close to zero error rate is the main reason for that.

Even though not often needed, there is no alternative system during down times of the Barkeeper. Problems like server crashes or camera problems have occurred.

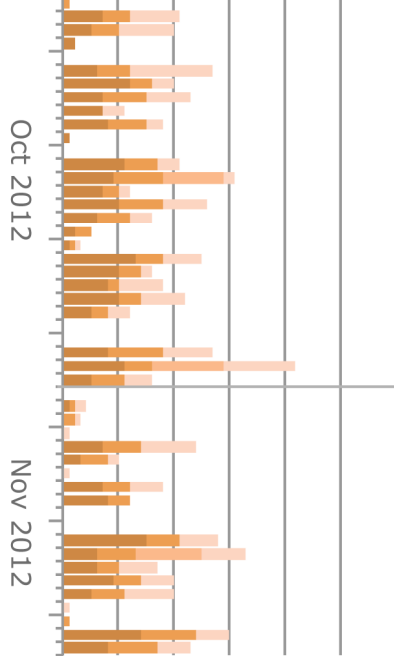
In the meantime, users had to remember their purchases to add the respective charges later. Without an alternative, forgetting of these purchases can easily occur. Downtimes of the system can be seen in the interactivity graph of the system and they are not followed by immediate purchase peeks. This means that some purchases were lost due to outages. A backup system would thus highly be appreciated, but currently still contradicts the zero cost policy.

Conclusion

In this paper, we presented the Barkeeper. We explained its design evolution and the long-term results of using such a visual marker-based system for consumption tracking in a group environment.

We showed how a collaboratively designed system can be quickly built in productive use to last over several years and that visual markers are a well-suited means for interaction with a kitchen-located system. Interestingly, although alternatives were provided, users preferred to use visual markers.

Though the use of single visual markers is slower than tally marks, users were able to build up own strategies for faster usage. Combined with additional enhancements such as combi-tags, the marker-based interaction can now even outperform tally marks in terms of speed. Still, most users stick to the standard single tag interaction as it integrates easily in their routines. This shows that performance on such a specific task might not be the most important factor of an interactive system. Even a slower interaction may be better suited for certain real-life interaction tasks if it integrates well into the usage scenario and is appealing to the user for other reasons.



The results of our user study and the qualitative data from the system itself showed that, although the system offers various possibilities for extended user privacy and security, users do not take advantage of those. Providing a mostly error-free and easily recoverable payment system leads to a trust level that is beyond security or privacy worries. We conclude that systems providing a high transparency of their inner workings and data handling can be more privacy invasive.

As the system's development has always been inspired by users' needs and ideas, they will definitely help to advance it in the future. The way some users individualize their tags with flags or special locations could be integrated in the standard workflow or tag design.

Acknowledgments

We want to thank our former colleague Raphael Wimmer for reminding us of important details; Gregor Broll for providing some excellent related work; Alexander Wiethoff for his input at the start of writing this; Anita Szász inspiring us to create the Barkeeper; Rainer Fink for keeping the server in a good shape; Denso Wave for inventing the QR codes and finally the former members of our lab that participated in the questionnaire. Besides this we want to thank the Barkeeper for being so patient with us and to all of you: QR amazing.

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