Policy and Internet

Crowdsourcing Public Opinion Using Urban Pervasive Technologies: Lessons From Real-Life Experiments in Oulu

Simo Hosio, Jorge Goncalves, Vassilis Kostakos, and Jukka Riekki

The civic potential of pervasive computing technologies has been increasingly explored within academic and urban planning communities. One vision is of communities and cities enriched with pervasive computing, where citizens can leverage the new technology and interfaces for their own purposes, and at the same time be empowered to be heard through the use of such technology. This article reports lessons learned from a project that created public human interfaces for interacting with city officials in Oulu, Finland. We focus on civic engagement and reflect on a deployment of public interactive crowdsourcing technologies that are openly available to everyone, right in the heart of the city. The series of field trials reported here involve public displays, mobile phones, and Internet technologies. We find differences in the performance of different kinds of input mechanisms, and present lessons learned from cooperating with officials in a joint civic engagement effort.

KEY WORDS: civic engagement, crowdsourcing, public displays, mobile phones, field trial, social networking services, polling, public opinion

Introduction

Should pervasive technologies empower citizens to interact with their city and participate in its decision-making processes, and if so, how exactly? One vision involves citizens leveraging pervasive computer resources for their own purposes, and at the same time being empowered to consciously participate in local issues through the use of technology. An example of this is formation of public opinion through use of publicly available technologies as crowdsourcing platforms. Here we report on progress made toward creating public interfaces for interaction between citizens and city officials in Oulu, Finland. The research project presented in this article was run by the authors in partnership with the Technical Centre of Oulu (TC). TC is a department of City of Oulu and is mainly responsible for maintaining all the city's public spaces. More specifically, in this article we explore an important societal issue, civic engagement, and discuss our experiments for evaluating pervasive technologies in the context of civic engagement.

1944-2866
Published by Wiley Periodicals, Inc., 350 Main Street, Malden, MA 02148, USA, and 9600 Garsington Road, Oxford, OX4 2DQ.

We argue that pervasive computing technologies in cities should be built primarily for their human inhabitants, and therefore humans and their contributions are the focus of our interest in this article. In particular, our overarching goal is to develop a systematic understanding of how citizens can interact with their everyday surroundings to provide value to the entire community, and the ways in which they leverage the technology and service infrastructure provided.

The first fundamental step in our work is to understand the possibilities afforded by the addition of new technological constructs, built as integral and permanent additions to shared urban spaces. We explore the potential role of pervasive technologies, namely public displays, in encouraging citizens to contribute to important local issues through crowdsourcing of public opinion. By partnering with local officials, the project has been able to foster civic engagement and provide a useful service to citizens. Our description of the field trials and the results obtained help outline and understand the challenges of civic engagement via public displays, as well as with cooperating with city officials in such projects. We highlight how citizen-feedback opportunities should be offered in a situated manner and how, despite the low amount of actionable feedback collected from citizens, the prototypes can still be considered as fit for their purpose.

Related Work

Civic Engagement

It is important to first acknowledge that a single universally accepted definition of civic engagement does not exist in the literature. The classic work *Bowling Alone* by Putnam (2000) has helped frame the wider context and explains how we are increasingly disconnected from our surrounding democratic structures. Further, Putnam (2000) provided tools and strategies to reconnect. Here, our emphasis is more narrowly on two particular notions put forth by Cooper and Cooper (2008) who state that for individuals: (i) engagement usually refers to participation in activities that benefit themselves and, often, their communities or society as a whole; and that (ii) engagement refers to participation and a sense of belonging in community, school, the workforce, and other aspects of life.

Clary and Snyder (2002), and later Montero (2004), have both noted that civic engagement can be highly beneficial for individuals, institutions, and communities as well as for the surrounding society in general. Hirschmann (1982) and Kelly and Breinlinger (1996) discuss in detail how civic engagement offers psychological and social benefits for the individual: satisfaction, sense of belonging, and social status rewards. To gain these benefits, individuals need to be persuaded to take action voluntarily. Thus, Bendapuni and Leone (2003) have encouraged citizens to adopt more active roles in society. However, several others, such as Huseby (2000) and later Alford (2001), have noted that in order to make real progress in civic engagement, reciprocal trust between people and responsible institutions must be introduced. Trust is obviously one of the key challenges and prerequisites of citizen participation.

Information technologies have emerged recently as means to better connect institutions and individuals. Bordewijk and van Kaam (1986) noted that the proliferation of computer technologies quickly augmented all areas of human communication, thus promising a great starting point for digital democracy to flourish. However, the enthusiasm for digital democracy, as explored by Dahlberg (2011), does not always stem from political parties hoping to enhance existing democratic processes, but also from anti-government libertarians who see potential for a complete realignment of these processes with the help of new, more efficient e-democracy technologies. In this article we argue for the former stance, that is, that those current democratic processes should be complemented —and not replaced—by new pervasive technologies. This approach is also advanced by Saad-Sulonen and Horelli (2012) in their exploration of civic engagement and information and communication technology–mediated participation in general, concluding that a holistic ICT-assisted approach to gathering and diffusing information is important in the future.

The deployments we present in this paper augment civic engagement right at the heart of the city. Their development and evaluation has been influenced by the pervasive computing literature, and particularly by literature focusing on interactive public displays (see e.g., Ananny & Strohecker 2009; Davies et al., 2012; Müller, Alt, Michelis, & Schmidt, 2010; Davies, Langheinrich, José, & Schmidt, 2012). We seek to provide a means for citizens to leverage such technologies to benefit the local community as well as the citizens themselves, conforming to the definitions of civic engagement and citizen participation outlined by Cooper and Cooper (2008).

Pervasive Technologies for Civic Discourse

The civic potential of pervasive computing technologies has been increasingly explored within academic and urban planning communities. For instance, Caragliu, Del Bo, and Nijkamp (2009) note that in some cases the addition of pervasive computational resources in our urban environments highlights the growing importance of ICTs in the social and environmental capital of cities. Another example comes from Ishida (2000), who argues that it is a step toward a more technology-laden connected community that utilizes communication networks and platforms to provide added value to citizens. Civic engagement is clearly one research domain that may benefit from communities being presented with better communication capabilities through the use of pervasive technologies.

Smart phones in particular have rapidly changed the contemporary communication landscape. Mobile participation, as argued recently by Ertiö and Ruoppila (2013), is rapidly transforming citizens from passive information foragers and receivers to human sensors capable of even complex output. Mobile phone penetration is globally at an all-time with billions of unique users, and smart phone users in particular are already accustomed to performing a variety of functions with their devices beyond just calling and texting their contacts. However, Goncalves et al. (2013) argue that in the context of crowdsourcing there

are several initial barriers when using only mobile phones, such as additional configuration efforts (e.g., installing apps, accessing Web pages) or even financial costs. In contrast to mobile-only environments, utilizing situated and public interfaces does not require citizens to make any extra effort to engage, or bear financial costs.

One such emerging situated technology for adding value to citizen's lives is interactive public displays. For example, Foth, Florian, and Satchell (2013) have discussed the future research directions of urban screens, highlighting how such resources no longer typically have just a single fixed purpose, and how they increasingly affect our everyday interactions in general. Davies et al. (2012) take a delightfully optimistic stance and compare their potential for human communications to that of radio, television, or the Internet. Further, Kuikkaniemi, Jacucci, Turpeinen, Hoggan, and Müller (2011) believe that, with successful design, much of the natural interaction in cities—lost following the proliferation of highly personal technologies such as the smartphone—can be reinstated. One way of looking at this development is to say that interactive public displays can make the city a more lively and joyful experience for its dwellers.

The considerations discussed above have motivated various experiments on societally meaningful services. In the context of civic engagement, some researchers are looking into how citizens can connect better with the city using display deployments. For instance, Schroeter, Foth, and Satchell (2012) report an in-depth study of the Discussions in Space (DIS) prototype, deployed in Brisbane, Australia. DIS allows users to post content publicly for authorities and passersby to view and interact with. The main message from these studies is that three major factors, namely people (audience), content, and location, all play a role in the projected success of a deployment. Hosio et al. (2012) have reported on a public display deployment that allows users to create content using public displays and then post it online, directly from the displays, for city officials to interact with. Their findings highlight the playfulness and general effectiveness of displays in reaching especially younger citizens.

Agora2.0, as explored by Schiavo et al. (2013), also combined the use of an online component and public displays to let users better connect to their political representatives through voting and posing simple questions. Situated voting has also been explored by Taylor et al. (2012), who presented Viewpoint, which poses opinions on a small screen from local officials and allows anyone to either disagree or agree using a short message service (SMS). Trials in Preston, UK with Viewpoint revealed a lack of trust from locals toward such technologies and the officials in general. However, the volume of simple poll answers obtained via the system was encouraging. Valkanova, Robert, Vande Moere, and Müller (2014) explored simple polling using public displays with their playful MyPosition prototype. MyPosition allows users to vote using gestures and large visualizations in the public space. The passersby of the week-long deployment in Preston, while playing with the installation, still demonstrated reliable voting behavior.

A prime example of longitudinal public display deployments in authentic settings (from the United Kingdom) is the Wray Photo Display described by

Taylor and Cheverst (2012). While the display's original purpose was not about civic engagement, but rather exploring the affordances of interactive screens by providing a shared photo board, the display has since been appropriated over the years for several civic purposes, such as creating a shared history of the area and promoting awareness of local official events. In the end it has become evident that the Wray Photo Display is capable of supporting the local community in various imaginative ways. Memarovic, Langheinrich, and Fatah gen. Schieck (2014) explain using media theory why interactive displays are particularly fitted for enriching the lives and communication of local communities. They describe how interactive displays allow users to leave their digital mark on the space, and how the displays act as extensions of us in that space. The local community is the focus of the project reported here as well.

The project intersects the two discussed research areas in several ways. The project team set out to foster civic engagement by attempting to create mutual and long-term benefits for individuals as well as for city officials. van Ingen and Bekkers (2013) have recently identified several pressing reasons for conducting such longitudinal studies. The project deployed a permanent grid of interactive displays at the heart of Oulu to allow citizens to better connect with city officials. At the same time, the performance of different types of input mechanisms were explored in this "messy" outdoor setting, as opposed to perhaps more moderated indoor settings where many of the similar technology deployments have taken place.

Rotuaari Renovation

The enabler of the work presented here was a large-scale renovation conducted at the very heart of the northern city of Oulu, Finland. The project involved an incremental effort to make the main pedestrian streets of downtown Oulu more pleasant through a complete overhaul and modernization of the streets. This included replacing the pavement and all street furniture, such as

Figure 1. Left: a conceptual image of one of the new streets (used with permission from Oulu Technical Centre). Right: a photo of the ongoing renovation.

benches and lamp-posts. An under-pavement heating system to keep the streets snow and ice free during the winter months was also built. This project posed a major disruption to everyday life in the city center, as can be observed in Figure 1 (right). In this context we present a series of case studies conducted using interactive public displays. The overarching objective of the project was to explore civic engagement in the form of collecting feedback about the renovation from citizens. We cooperated with local city officials from the TC, which is in charge of executing and supervising the entire renovation project.

Research Approach

In the study we follow "deployment-based research" as defined by Alt, Schneegaß, Schmidt, Müller, and Memarovic (2012) in the context of public displays. They refer to it as research that introduces displays into a social setting, such as a city, to explore a variety of research questions. Then, based on results and findings, an iterative process is employed to improve the deployment. Further, we incorporate external expertise into the development and evaluation. Working together with external domain experts, such as the TC in this case, is a highly recommended practice in all application-led research (see e.g., Sharp & Rehman 2005), and has been shown to lead to additional insights and findings (Hosio et al., 2012; Taylor et al., 2012). Also, following the suggestion by Brown, Reeves, and Sherwood (2011), we attempt to avoid bluntly classifying any trial results as either "good" or "bad," but aim to understand and objectively describe how the deployment fared and interacted with its users in the given context.

Research Environment and Methods

Hosio et al. (2012) have already described how the displays were used as a vivid visual element in the city, enabling direct dissemination of information and constituting a novel and appealing channel for dialogue and engagement with their users. The displays have been deployed since 2009 and citizens and visitors can freely use them in a true 24/7 fashion. The 57" touch-capable displays are also *multipurpose*: at any given time they provide access to a variety of different applications. This is unlike several related deployments of public displays that feature a single application or service, usually for commercial or short-lived purposes. Multipurpose displays offer a variety of services to their users including directory services, news and weather, image and video galleries, quizzes and polls, and games. During the studies, 10–16 functional screens were available for use at all times, both outdoors and indoors. Authentic in situ depictions of the displays can be seen in Figure 2.

The displays form the world's largest public display network that is available for research purposes 24/7, giving researchers a unique opportunity to experiment in a realistic test bed with thousands of un-coached users. For the studies presented in this article we developed a civic-themed crowdsourcing application.

Figure 2. Public interactive displays in Oulu: two double-sided outdoor displays on the same streets that were under renovation and one single-sided indoor display in a local swimming hall.

To ensure the deployment was an authentic insertion into the city fabric, the application was not given any particular priority on the screens; it was simply deployed as one service among all the others on the displays' application directories. More details on the directory mechanism used on the displays can be found in Ojala et al. (2012).

The displays and their applications have a fairly steady user base. During the deployment months, the total application launches on all displays was approximately 9,000 per month. Typically games have been very popular on the displays, with over one-third of all screen usage, if measured by application launches. A detailed examination of the application launches and their relative popularities during the project is, however, challenging. During the study several new applications were introduced, old ones removed and changed, menu structures changed, and hardware downtime and other disturbances were experienced as a result of the renovation. Along the same lines, Hosio, Goncalves, and Kostakos (2013) have noted that evaluating single applications on multipurpose displays should not directly consider the popularity of the other applications, but the evaluation focus should be on the application's performance in regard to its own purpose. For an in-depth discussion about the infrastructure, its typical use, and social practices around the displays, the reader should consult the report by Ojala et al. (2012).

The local officials managing the project, the TC, typically use both print and online media to disseminate information about their ongoing activities. At the time their website featured feedback forms, but according to the TC these were not used at all by citizens. Local business owners frequently called or emailed the TC to discuss practical issues such as pedestrian flows to their stores. However, citizens typically did not voice their opinions or concerns about the renovation to the officials at all. For this reason, the TC wanted to explore the potential of pervasive technology to address both the need for information dissemination and collection of feedback from citizens.

So, to conduct the study, we teamed up with two key engineers from TC in charge of supervising the construction work. We organized two initial meetings (one at their premises, one at our campus at University of Oulu) to discuss the project, and followed up on the application design via informal email discussions.

After each prototype deployment, an informal email exchange took place. With the emails we could assess their satisfaction and opinions about the success of each of the deployments. In addition, two major evaluation meetings took place, one in the middle of the project and one in the end, where we discussed the project results so far. During the deployment, teams of research assistants were deployed downtown to conduct in situ interviews with pedestrians using the displays and the prototypes. The questions were informal and open-ended, but during each prototype the new user interface and input features and their usability were a particular focus of discussion.

The Prototype Deployments

Our deployment towards enhancing civic engagement in the presented context consisted of a prototype system for the TC to distribute information about the renovation project and provide citizens with an easy-to-use feedback channel on the public displays. More specifically, our joint goal with the TC was to evaluate different mechanisms for citizens to provide feedback through the system. The initial—ambitious—goal was to also adjust certain operations of the TC, in real time, based on the feedback. We adopted an iterative development cycle whereby the feedback application performance was assessed in terms of the quantity and quality of collected feedback at certain intervals. The analysis then led us to design alterations for the next deployment period.

We ended up deploying four incremental prototypes (P1–P4) over a period of 2 years. P1 was tested for 3 months during the summer of 2011, which was the first summer that the renovation took place. Prototypes 2–4 were each deployed sequentially for 1 month during the summer of 2012, the second phase of the renovation. Between these periods the application was decommissioned from the displays, given the renovation only took place during the summer months, and did not disturb the daily life in downtown Oulu during the time between. When launched on the multipurpose displays, the feedback interfaces shown in Figure 3 occupied the right half of the 57″ screens (Figure 2). The purpose of each iteration was to collect empirical data on civic engagement and to generate recommendations for the next iteration of the prototype. We now briefly describe the prototypes and the response they received.

Figure 3. The feedback interfaces of Rotuaari Renovation application. From left: P1, P2, P3, and P4.

Prototype 1: Situated Feedback. The initial prototype (P1, Figure 3) enabled citizens to use the public displays to provide open-ended text feedback on the renovation project. We based our design on earlier experience from other applications on the displays that successfully incorporated on-screen virtual keyboards for typing, as presented in the studies by Hosio et al. (2012) and Goncalves, Hosio, Liu, and Kostakos (2014). The feedback messages collected by the displays were automatically sent to the TC without moderation.

P1 was launched 1,406 times, and 35 feedback messages were dispatched to the TC. Two researchers categorized the feedback into "relevant" and "not relevant" messages, depending on whether or not they offered feedback on the renovation. Eight of the 35 items were found to be "relevant." The relatively high number of irrelevant messages (77.1 percent) suggested that the feedback collected by the prototype had a high noise level (where we define noise as messages that are not related to the renovation project).

Despite this, an interview with the TC revealed that they were, in fact, very satisfied with the aggregated results: they regarded P1 an original and novel channel that was perceived to be beneficial by citizens. It served as a nice addition to their public image as an innovative and technically advanced organization. Interviews with citizens who were interrupted by researchers while they were seen using the displays during the final weeks of P1 deployment revealed that indeed it was seen as one of the most useful and interesting applications deployed at the time on the screens in Oulu. This was because of its perceived high relevance to a local and topical issue. The feedback channel was new to citizens and the idea was received positively, even if the prototype itself did not receive the heavy usage we would have expected. An issue that was frequently noted in the interviews was how difficult the virtual keyboard is to use: it is physically cumbersome, or even "painful," and users demanded more familiar input mechanisms such as using their personal computers and smartphones.

Prototype 2: Situated Polling and Off-Screen Feedback. The second prototype (P2, Figure 3) was used to evaluate the effect of providing multiple feedback channels, utilizing both the public displays as well as personal mobile devices carried by citizens. As requested by citizens in the previous interviews, the feedback mechanism on the displays was simplified by removing the on-screen keyboard, and we also added an emoticon-like interface where "smiley faces" were used to rank personal agreement on two statements defined by the TC:

Statement 1: "*The large renovation project is topical and necessary for Oulu!*"

Statement 2: "*The City officials are informing citizens sufficiently about the renovation project!*"

The smileys were captioned using standard 5-point Likert-scale statements from "strongly disagree" to "strongly agree," from left to right. Citizens had to rate both statements and touch a "send button" to register their ratings. The displays encouraged citizens this time to submit more detailed feedback through their personal mobile devices using either text messages (SMS), email, or by

sending a message with a certain hashtag to Twitter. Both SMS and Twitter have previously been used successfully in conjunction with public displays for feedback, for example in studies by Ananny and Strohecker (2009) or Munson, Rosengren, and Resnick (2011), and several participants interviewed about the previous prototype had suggested using something quicker and more effortless than virtual keyboard on the public display.

During the 1-month deployment of P2 it was launched 381 times, rather disappointingly resulting in no feedback via email, SMS, or Twitter. A total of 20 smiley submissions were made with an average rating of 3.8 (SD: 1.5) and 3.4 (SD: 1.6) for statements 1 and 2, respectively. Similar informal, in situ interviews as conducted during P1 with pedestrians using the prototype now revealed that smileys were preferred to the text-based feedback mechanisms. Interviewees claimed that email would be their favorite choice, but also that leaving feedback later, for example at home and out of context, was very unlikely. Ironically, the majority of respondents expressed the need for a virtual keyboard because they felt it would be the most straightforward way to submit feedback instantly. In summary, we found that citizens were reluctant to devote effort to using any of the three text-based feedback mechanisms offered, all of which required the use of personal devices. The interviews highlighted, once more, the need for effortless, in situ feedback mechanisms.

Prototype 3: Real-Time Stream With Off-Screen Feedback. In this prototype (P3, Figure 3) we attempted to test a motivational approach to increase the use of the smartphone-based feedback mechanisms. For this reason we added a "stream" of the 10 latest messages received through all of the text based channels (SMS, email, Twitter) to the interface to allow for discussions to take place. This is a practice suggested by Redhead and Brereton (2006) for enhancing communication between community members on public displays. We hypothesized that this would motivate feedback submission by letting users observe others' messages, which in turn enhances sense of community, a motivator for participation in urban settings, as also discussed by Chavis and Watersman (1991). The stream of messages on the public displays was moderated by the researchers to remove offending and irrelevant comments.

During the 1-month deployment of P3, the application was launched 444 times, resulting in six text-based feedback messages, all via SMS, and 46 smiley responses. Similar to the data from P1, text messages were categorized into "relevant" and "not relevant" by two of the authors of this article, and all six were coded as unanimously relevant. The average agreement ratings given by the emoticon-like on-screen mechanism were 4.4 (SD: 1.2) and 4.3 (SD: 1.1) for each statement. Overall, we observed that the introduction of the message stream clearly encouraged users to leave textual feedback and use the smiley mechanism more.

Prototype 4: Real-Time Stream With Situated Feedback. In the final prototype (P4, Figure 3) we removed the smiley mechanism because we felt it was limited in

richness of feedback. We also removed the SMS/email/Twitter channels and instead deployed the virtual keyboard mechanism from P1. This time, however, we complemented it with the messages stream from P3, as we anticipated it would enhance both participation and quality if used in conjunction with the virtual keyboard.

During the 1-month deployment P4 launched 433 times, and we received 40 feedback messages originating from the virtual keyboard. Two of the authors again categorized the new messages into "relevant" and "not relevant," resulting in 13 relevant comments and 27 irrelevant ones (unanimously). Thus, the percentage of noise was approximately the same as in P1, at 67.5 percent.

The final interview with the TC revealed that they were still satisfied with the positive exposure they were getting through our deployments, and that the prototypes were valued especially in building public relations and the image of their activities in general. The TC also regarded the grid of public displays as a promising medium to better connect with citizens, keeping in mind the fact that their previous channels had resulted in practically no feedback from citizens at all. Our deployments were the sole channel citizens used to voice their opinions and feedback to the TC about the renovation project.

Examples of Obtained Feedback. To summarize, the prototypes were used 2,664 times in 6 months, and 81 feedback entries were submitted via it. Twenty-seven of the entries were categorized as meaningful in regard to the renovation project. The smiley mechanism was used 66 times during 2 months of deployment time. It is important to discuss the kind of content submitted by the public. Both negative and positive aspects were highlighted by citizens. Positive comments included: "More employees are needed, this needs to be done faster," "Looking good, also the new stage looks nice!," and "It's great to see the City developing!" When the stream was deployed in combination with the keyboard (P4), discussions started to take place: "Wasting years because of this small renovation is way too long," "Also, please add more working hours, it is taking too long," and "Yeah, I also really agree on that" were posted sequentially to the stream. This suggests that adding the comment stream led to further engagement with other citizens. However, throughout the study strong appropriation of the used technology led to high noise levels in the received feedback. Comments such as "It's fun in Oulu," "hello everyone," "I like beer at nights," random character strings, nicknames (probably the nicknames of the commenters themselves), swearwords, and other profanities were often submitted using the prototypes.

The strong noise level in the responses illustrates that citizens are highly prone to use new pervasive infrastructure for their own needs, in their own time, in a way that is highly dependent on the deployment context and that often goes far beyond the original intentions of the technology designers. This in turn raises issues around moderation: whose responsibility, if anyone's, is it to moderate the feedback from citizens and when? These issues are nothing new per se, and have already been discussed several times in the context of pervasive technologies, for

example recently by Memarovic, Langheinrich, Cheverst, Taylor, and Alt (2013), Ylipulli, Suopajärvi, Ojala, Kostakos, and Kukka (2014), and Schroeter et al. (2012). While people's seemingly random ways of interacting with new tech deployments can be seen as a challenge, it is also at the same time promising, and indicates the public's willingness to use public deployments of interactive technologies instead of regarding it as an oddity to be avoided.

Discussion

The ideas and findings explored in this article do not necessarily apply in all other contexts and cultures. This is not a limitation per se, but rather means that the discussed concepts should be revalidated when introduced in a new context. As Brown et al. (2011) note, the inevitable variability of public trials makes them difficult to reproduce even with the best efforts of researchers. However, many overarching lessons from our work carry over into other environments. This section discusses the most valuable insights that surfaced during the prototype deployments.

Cooperating With Officials

Although teaming up with relevant officials is considered good practice in application-led research by Sharp and Rehman (2005), it introduces extra overhead and burden. For instance, we would have initially preferred experimenting with rich media formats (e.g., video, audio, images, interactive maps, etc.). In the design meetings with the TC, however, we had to strike a balance between novelty (which is often highly appreciated in research) and functionality. Functionality and familiarity obviously were the number one priorities for the TC; the officials wanted the feedback sent directly to their email in an easily digestible format. Thus, we ended up using mainly text-based input mechanisms. The smileys, added in P2, produced equally easy to digest results, that is, a straightforward average of the given ratings. In hindsight, the text-only feedback was not a major issue in the deployments, as interviewees voiced such comments as "No audio or video anywhere, I don't want to use my face or voice. Text or multiple-choices work fine." and "I would find it very awkward to talk to a machine in video or audio feedback, so text is still the best…" Only very few interviewees indicated a willingness to use voice or video in the public space for leaving feedback.

Another issue with the TC was different expectations of results; mainly because we had a different notion of "success" from the TC. We, as researchers, contrast the results with our own earlier studies, related studies, and would like to observe as high a volume of feedback as possible. In the end, we were slightly disappointed about the amount. However, in deployments like these we must remember the original purpose of the deployment. It was to rely on already built technological additions, and use these to improve the existing outreach channels of the TC. In other words, we did not aim to maximize input via means of

novelty, playfulness, or disruptive interventions. Even so, evaluating the results with the officials revealed that our solution was able to reach otherwise difficult to reach citizens—a fact that was highly appreciated. In addition, the TC gained information on how different feedback mechanisms really work in the city, and to our surprise they were happy with the added value of the application. In particular they expressed that the PR value boosted their public perception as a modern organization (We can't evaluate if it indeed did so, though, given we didn't measure the public perception of the TC).

Finally, we learned that citizens should be made aware, as transparently as possible, of what impact their potential participation will, or may, have. Hosio, Goncalves, Kukka, Chamberlain, and Malizia (2014) have described how initial engagement deployments are easy to "sell" to third parties, because they essentially get something for nothing. What is difficult, then, is guaranteeing officials' commitment to civic engagement projects in the long term. This was certainly an issue in our case. It became obvious in our informal discussions during the later phases of the trials that it would actually have involved a very complicated bureaucratic process to make any real changes to the construction work that had already been planned based on public opinion only. The important end goals of deployments are easy to forget when designing the visible front end of a deployment. It is important to inform the citizens very transparently from the beginning about the possible impact of participation. Naturally this also requires ensuring that the involved officials are willing to foster cooperation during the entire lifespan of a joint project—a crucial challenge to keep in mind with all public civic tech deployments.

Feedback in the City: Everywhere or Situated?

Our results suggest that citizen feedback mechanisms often benefit from being highly situated. Our interviews in particular suggest that for a feedback channel to be effective it needs to be made available at the right time, in the right context. This is in line with previous research on civic engagement by Ananny and Strohecker (2009), suggesting that feedback mechanisms—whether for an online community, a service, or presumably a city—can be more effective when they are situated. Battino, Van de Moere, and Barsotti (2011) describe public displays as highly situated technology by their very nature, and how they are perceived as an integral part of a place's identity and character. Along the same lines, Memarovic et al. (2014) compared displays as natural extensions to ourselves and our capabilities in a space. Thus, utilizing them as a channel for instant contextual feedback is a compelling use case. During our interviews several respondents voiced a preference for fast, situated feedback mechanisms that are easily available at the right time—the time when they are actually downtown and can see the renovation first hand—instead of having to go online once they get back home and recall the feedback they wanted to give. Examples of such opinions include "Yes, I would use public displays easily spontaneously, for example, right after [something to comment on]" and

"Feedback about spur-of-the-moment things would perhaps be reported using public displays."

At the same time, responses such as "I would not give very negative or enthusiastic feedback in public," or "I would probably think more if I was at home using a web application" imply that utilizing a multi-channel approach, as also suggested by Saad-Sulonen and Horelli (2012), is a good idea. Citizens should be allowed to act quickly, in situ, or to think more thoroughly about the issue and leave perhaps more in-depth output later on, online or via mobile means. This is also pointed out by Goncalves et al. (2014) who emphasize the role of public displays as the engagement initiator. That is, a display can create awareness of the participation possibilities, and then users may well opt to use other channels for the actual interaction.

So, while public displays as a platform are promising in terms of initiating and providing civic engagement opportunities, the effectiveness of the actual feedback mechanisms becomes crucial. In our particular case it was important for the TC to offer text-based solutions. Virtual keyboard, SMS, Twitter, and email were all evaluated for this purpose, and their differences turned out to be significant, as we discuss next.

The Channel Still Matters

The first discussed case study focused on comparing different input mechanisms in an otherwise identical environment. In P2 when SMS, Twitter, and email channels were deployed to facilitate easier typing and to lessen noise, the amount of feedback dropped to zero. This highlights the need for effortless, in situ interaction mechanisms for crowdsourcing that requires the least amount of effort from the participants (Goncalves et al., 2013). In Finland at the time of the studies, Twitter was scarcely used and while smartphone penetration is rapidly growing, by no means does everyone have email capabilities on their mobile phones. What was unexpected in the use of SMS, compared to the use of virtual keyboard, is the quality of feedback it produced. All the messages submitted through SMS (during P3) were relevant to the renovation project. We attribute this to the cost of SMS, which in Finland is approximately 0.07EUR per message. This price may seem low, but Shampanier, Mazar, and Ariely (2007) note that there is a substantial difference in perception between zero cost and anything above that. As our results suggest that only people who were serious in voicing their feedback were willing to pay for it, we believe that requiring even a minimal payment from citizens is effective in filtering out much of the noise from their feedback. Obviously with such low level of participation in our study (SMS $N = 6$), we do not claim to have statistically significant data, but the reduced amount of noise does highlight an important trade-off in developing our environments. That is, should the infrastructure be free at the point of use or not? Our study suggests that this trade-off is manifested in terms of quality of citizen contribution and participation levels when considering civic engagement in a modern city. Obviously there is no single correct solution to this, and this is a design choice to be made by developers.

The message stream in P3 and P4, which allowed people to observe others' contributions, substantially enhanced civic engagement. Memarovic et al. (2015) note how leaving a "digital footprint" on a public display, that is, in this case a comment, stimulates curiosity and participation of potential users, as they may wish to contribute after seeing content contributed by other community members. In our case the stream enabled discussions between the community members around the renovation project on public displays. An analogy can be made with online message boards, which can be conceived as democratic meeting places, or virtual agoras. The underlying value of such boards comes from anonymous, fairly unstructured discussion that allows users to post what they want instead of what the officials want to hear. This shift in power has a liberating effect, as topics and concerns that people are interested in arise, including ones the officials might not necessarily be aware of. The egalitarian nature of our public displays, which allow anyone to walk up to them and use them to contribute to the ongoing discussion, acted as a catalyst for engagement. Furthermore, rather than the infrastructure hiding away the events and actions taking place, the stream revealed these to citizens and as a result engaged them. This can be partially explained by earlier thoughts of Hirschmann (1982), who argued that collective action is morally gratifying and conveys direct benefits to individuals, even when the actual end results are not yet guaranteed.

We also uncovered insights in the interviews that prove that not all voting systems are created equal. The use of smileys was found suitable by many in this case, as they allow a broad range of emotion, that is, they are descriptive enough. Responses that support this include "Smileys are fast and easy, even a child can grasp their meaning intuitively" and "I like smileys, they're simply way more interesting than just a [yes/no] checkbox." This suggests that while, for example, Viewpoint by Taylor et al. (2012) might elicit more input, citizens are not always happy expressing just a "yes" or "no" in matters of importance.

However, and as mentioned earlier, participants still preferred to have multiple channels at their disposal, based on their participation preferences. While smileys were liked, several participants implied that they would in addition enjoy the choice to participate via, for example, email if they had more to say: "Smileys are handy and fast. With an email I could then justify my answer" or "Textual feedback is not 100% necessary, but it is a handy addition [to the smileys]."

Toward Open Civic Engagement

Despite the low volume of feedback in our study, we argue that as pervasive technology matures from concepts into reality it will become increasingly important to harness the power of the crowd, to crowdsource public challenges. In previous studies with similar technology, but tailored to a younger clientele, utilizing playful design, and deployed in more controlled settings, Hosio et al. (2012) showed that public displays can be successful in eliciting high numbers of

relevant feedback in a much shorter period of time. Because it is typically the young who are most aggressive in adopting the new technology, perhaps they feel most comfortable being vocal citizens, the pioneers of open civic engagement. Therefore, as Clary and Snyder explained (2002), a major ongoing challenge is to also attract adults to participate and break their deeply ingrained habits of remaining inactive in community-driven participation.

Deployments in controlled settings and with narrow demographics, such as only involving young people, are highly effective in quickly testing a new technology concept. However, in order to make a long-lasting impact the technology to connect with citizens has to be available "in the wild" in our everyday surroundings. For instance, the Wray Photo Display by Taylor and Cheverst (2012) is a great example of making a long-lasting impact in the local community by persistent deployment efforts. Further, open civic engagement can only happen when equal opportunities for participation are provided; age, gender, or any other factors must not limit the access to the new technologies. Therefore, we advocate deployments in the urban space around us.

As also noted by Müller et al. (2010), this space is a rich yet challenging environment within which to deploy infrastructure and applications. Several considerations, including the intertwined social practices of the space, the robustness of the technology, vandalism, differing stakeholder interests, and even weather conditions bring about constraints when deploying technology in such authentic settings. These are all details that we had to confront during our long-term experiments. However, these challenges are critical to shaping our understanding of citizen's use of our technology. This insight has been voiced before, with for example, Sharp and Rehman (2005) arguing that to gain an understanding of how new, openly accessible technology is received and especially appropriated by the general public, deployment in such environments, or living laboratories, is indeed required.

A key factor in obtaining reliable results in open environments is understanding users' intentions, or their seriousness. In our trials we observed a lot of non-relevant feedback, that is, noise. Müller et al. (2010) explain that particularly with public displays, users often lack a clear motive when starting to use them. In addition, Hosio et al. (2013) show that the vast majority of service launches on multipurpose displays may originate from pure curiosity rather than an intention to actually use a service, thus leading to decreased seriousness.

In our vision it is clear that computational resources such as public displays should be capable of serving several different use cases, to be multipurpose. This naturally has implications for future civic deployments in public, as services have to compete for popularity. For a thorough comparison of different themed applications on the screens, we again refer the reader to Ojala et al. (2012). So, when users are offered a myriad of options, it becomes more important than ever to be able to offer interesting and appealing content. Making the situation even more challenging for civic engagement is that it simply lacks mass appeal, as discussed by van Ingen and Bekkers (2013). In our environment it seems to be

games that are most attractive to the public, and we have since started to exploit this opportunity. We are currently experimenting with gamification as one of the design elements in our future installations.

Conclusions

Creating public human interfaces for interacting with our surroundings is challenging but in our opinion worthwhile. In this article we have focused on an important societal issue—civic engagement—in the context of interactive public technologies that crowdsource public opinion. The study is rather unique, as we utilized multipurpose technologies, and our deployment was openly competing for popularity against several other applications offered. The display infrastructure used in our trials is not a novel research intervention, but an established part of the city fabric. Perhaps counterintuitively, this is a good thing. Such an environment allows for longitudinal deployments, which are seen as beneficial in the context of civic engagement by (e.g.) van Ingen and Bekkers (2013). Deploying applications on the display network in Oulu yields highly realistic results about how civic engagement can be fostered by officials. These are a fair yardstick with which to compare future results in other equally established public infrastructures.

We highlight that designing multi-channel systems should be considered when possible. Citizens are simply not always in the mood, or even capable, to participate with only one offered means. And civic engagement should be available for all walks of life, as noted by Mohammadi, Norazizan, and Shahmadi (2011). Another issue is that as researchers we commonly have to strike compromises when cooperating with officials. This has to be reflected in the project expectations and especially in evaluating results. Success as defined by researchers is often very different from success in the eyes of the involved officials. In our case, we were certainly disappointed by the low volume of responses, but the officials were happy with the achievements and willing to continue supporting the deployment. Finally, supporting discussions emerges as a good design implication to elicit more meaningful input in urban contexts. In situated deployments, it makes sense to allow people to leave a kind of footprint, to show the participants that they are not the only ones using the system, and therefore to create a feeling of collective action as well as personal satisfaction.

We conclude by noting that a city does not just somehow magically become open toward its citizens, nor can it start offering permanent solutions for civic engagement overnight. For this reason we emphasize conducting longitudinal experiments in collaboration with authorities and citizens. We believe that permanent and situated installations, such as our public interactive displays, can be harnessed to provide cost-effective interaction opportunities for the future city and its citizens. Indeed, the study presented here is by no means a one-off endeavor, but a part of a greater effort of connecting citizens to different authorities and municipal actors in our city. At the time of writing this article we

have several other civic services deployed on top of our public display infrastructure, and the lessons from the trials presented in this article have been a great help in designing the ongoing experiments.

Simo Hosio, Ph.D., Department of Computer Science and Engineering, University of Oulu, Oulu, Finland [e-mail: simo.hosio@ee.oulu.fi].
Jorge Goncalves, M.Sc., Department of Computer Science and Engineering, University of Oulu, Oulu, Finland.
Vassilis Kostakos, Ph.D., Professor, Department of Computer Science and Engineering, University of Oulu, Oulu, Finland.
Jukka Riekki, Ph.D., Professor, Department of Computer Science and Engineering, University of Oulu, Oulu, Finland.

References

Alford, J.R. 2001. "We're All in This Together: The Decline of Trust in Government, 1958–1996." In *What Is It About Government That Americans Dislike*? eds. J.R. Hibbing, and E. Theiss-Morse, Cambridge: Cambridge University Press, 28–46.

Alt, F., S. Schneegaß, A. Schmidt, J. Müller, and N. Memarovic. 2012. "How to Evaluate Public Displays." In *Proceedings of the First International Symposium on Pervasive Displays*. New York: ACM, Article No. 17. http://dl.acm.org/citation.cfm?id=2307815.

Ananny, M., and C. Strohecker. 2009. "TexTales: Creating Interactive Forums With Urban Publics." In *Handbook of Research on Urban Informatics: The Practice and Promise of the Real-Time City*, ed. M. Foth, Hershey, PA: IGI Global, 68–86.

Battino, P., A. Vande Moere, and V. Barsotti. 2011. "Situated & Social Feedback in the City." In *Workshop on Large Displays in Urban Life From Exhibition Halls to Media Facades*. In Extended Abstracts of the *2011 Conference on Human Factors in Computing Systems*. New York: ACM, 2433–6.

Bendapuni, N., and R.P. Leone. 2003. "Psychological Implications of Customer Participation in Co-Production." *The Journal of Marketing* 67 (1): 14–28.

Brown, B., S. Reeves, and S. Sherwood. 2011. "Into the Wild: Challenges and Opportunities for Field Trial Methods." In *Proceedings of the 2011 ACM CHI Conference on Human Factors in Computing Systems*. New York: ACM, 1657–66. http://dl.acm.org/citation.cfm?id=1979185.

Bordewijk, J., and B. van Kaam. 1986. "Towards a New Classification of Tele-Information Services." *Intermedia* 14 (1): 16–21.

Caragliu, A., C. Del Bo, and P. Nijkamp. 2009. "Smart Cities in Europe." Series Research Memoranda 0048. VU University Amsterdam, Faculty of Economics, Business Administration and Econometrics.

Chavis, D., and A. Watersman. 1991. "Sense of Community in the Urban Environment: A Catalyst for Participation and Community Development." *American Journal of Community Development* 18 (1): 35–81.

Clary, E.G., and M. Snyder. 2002. "Community Involvement: Opportunities and Challenges in Socializing Adults to Participate in Society." *Journal of Social Issues* 3: 581–92.

Cooper, M., and G. Cooper. 2008. *Overcoming Barriers to the Positive Development and Engagement of Ethno-Racial Minority Youth in Canada*. Calgary: Canadian Heritage.

Dahlberg, L. 2011. "Re-Constructing Digital Democracy: An Outline of Four 'Positions."' *New Media & Society* 13 (6): 855–72.

Davies, N., M. Langheinrich, R. José, and A. Schmidt. 2012. "Open Display Networks: A Communications Medium for the 21st Century." *Computer* 45 (5): 58–64.

Ertiö, T., and S. Ruoppila. 2013. "Contributing On-the-Go: Participatory Planning Apps." Paper presented at the 2013 European Urban Research Association Conference, July 3–6, Enschede, the Netherlands.

Foth, M., F. Florian, and C. Satchell. 2013. "From Movie Screens to Moving Screens: Mapping Qualities of New Urban Interactions." Paper presented at the 4th MediaCities Conference, May 3–5, Buffalo, NY.

Goncalves, J., D. Ferreira, S. Hosio, Y. Liu, J. Rogstadius, H. Kukka, and V. Kostakos. 2013. "Crowdsourcing on the Spot: Altruistic Use of Public Displays, Feasibility, Performance, and Behaviours." In *Proceedings of the 2013 ACM International Joint Conference on Pervasive and Ubiquitous Computing*. New York: ACM, 753–62. http://dl.acm.org/citation.cfm?id=2493481.

Goncalves, J., S. Hosio, Y. Liu, and V. Kostakos. (2014) "Eliciting Situated Feedback: A Comparison of Paper, Web Forms and Public Displays." *Displays* 35 (1): 27–37.

Hirschmann, A.O. 1982. *Shifting Involvements: Private Interest and Public Action*. Princeton, NJ: Princeton University Press.

Hosio, S., J. Goncalves, and V. Kostakos. 2013. "Application Discoverability on Multipurpose Public Displays: Popularity Comes at a Price." In *Proceedings of the 2nd International Symposium on Pervasive Displays*. New York: ACM, 31–6. http://dl.acm.org/citation.cfm?id=2491576.

Hosio, S., J. Goncalves, H. Kukka, A. Chamberlain, and A. Malizia. 2014. "What's in it for Me: Exploring the Real-World Value Proposition of Pervasive Displays." In *Proceedings of the Third International Symposium on Pervasive Displays*. New York: ACM, 174–9. http://dl.acm.org/citation.cfm?id=2611012.

Hosio, S., V. Kostakos, H. Kukka, M. Jurmu, J. Riekki, and T. Ojala. 2012. "From School Food to Skate Parks in a Few Clicks: Using Public Displays to Bootstrap Civic Engagement of the Young." In *Proceedings of the 10th International Conference on Pervasive Computing*. Berlin Heidelberg: Springer, 425–42. http://dl.acm.org/citation.cfm?id=2367345.

Huseby, B.M. 2000. *Government Performance and Political Support: A Study of How Evaluations of Economic Performance, Social Policy and Environmental Protection Influence the Popular Assessments of the Political System*. Trondheim: Department for Sociology and Political Science.

Ishida, T. 2000. *Understanding Digital Cities. Digital Cities: Technologies Experiences and Future Perspectives, 2000*.

Kelly, C., and S. Breinlinger. 1996. *The Social Psychology of Collective Action: Identity, Injustice and Gender*. London: Taylor & Francis.

Kuikkaniemi, K., G. Jacucci, M. Turpeinen, E. Hoggan, and J. Müller. 2011. "From Space to Stage: How Interactive Screens Will Change Urban Life." *Computer* 44 (6): 40–7.

Memarovic, N., gen. Fatah A. Schieck, H. Schnädelbach, E. Kostopoulou, S. North, and L. Ye. 2015. "Capture the Moment: 'In the Wild' Longitudinal Case Study of Situated Snapshots Captured Through an Urban Screen in a Community Setting." In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing*. New York: ACM, 242–53. http://dl.acm.org/citation.cfm?id=2675133.2675165.

Memarovic, N., M. Langheinrich, K. Cheverst, N. Taylor, and F. Alt. 2013. "P-LAYERS—A Layered Framework Addressing the Multifaceted Issues Facing Community-Supporting Public Display Deployments." *ACM Transactions on Computer-Human Interaction* 20 (3). New York: ACM, Article No. 17. http://dl.acm.org/citation.cfm?id=2491505.

Memarovic, N., M. Langheinrich, and gen. Fatah A. Schieck. 2014. "Community Is the Message: Viewing Networked Public Displays Through McLuhan's Lens of Figure and Ground." In *Proceedings of the 2nd Media Architecture Biennale Conference: World Cities*. New York: ACM, 30–3. http://dl.acm.org/citation.cfm?id=2682891.

Mohammadi, S.H., S. Norazizan, and A.R. Shahvandi. 2011. "Civic Engagement, Citizen Participation and Quality of Governance in Iran." *Journal of Human Ecology*, 36 (3): 211–6.

Montero, M. 2004. *Introducción a la psicologia comunitaria*. Paidos, Buenos Aires.

Müller, J., F. Alt, D. Michelis, and A. Schmidt. 2010. "Requirements and Design Space for Interactive Public Displays." In *Proceedings of the 2010 International Conference on Multimedia*. New York: ACM, 1285–94. http://dl.acm.org/citation.cfm?id=1874203.

Munson, S.A., E. Rosengren, and P. Resnick. 2011. "Thanks and Tweets: Comparing Two Public Displays." In *Proceedings of the 14th ACM Computer Supported Cooperative Work*. New York: ACM, 331–40. http://dl.acm.org/citation.cfm?id=1958875.

Ojala, T., V. Kostakos, H. Kukka, T. Heikkinen, T. Linden, M. Jurmu, S. Hosio, F. Kruger, and D. Zanni. 2012. "Multipurpose Interactive Public Displays in the Wild: Three Years Later." *Computer* 45 (5): 42–9.

Putnam, R.D. 2000. *Bowling Alone: The Collapse and Revival of American Community*. New York: Simon & Schuster.

Redhead, F., and M. Brereton. 2006. "A Qualitative Analysis of Local Community Communications." In *Proceedings of the 18th Australia Conference on Computer-Human Interaction: Design: Activities, Artefacts and Environments*. New York: ACM 361–4. http://dl.acm.org/citation.cfm?id=1228245.

Saad-Sulonen, J.C., and L. Horelli. 2012. "The Value of Community Informatics to Participatory Urban Planning and Design: A Case-Study in Helsinki." *The Journal of Community Informatics* 6 (2). http://ci-journal.net/index.php/ciej/article/view/579.

Schiavo, G., M. Milano, J. Saldivar, T. Nasir, M. Zancanaro, and G. Convertino. 2013. "Agora2.0: Enhancing Civic Participation Through a Public Display." In *Proceedings of the 6th International Conference on Communities and Technologies*. New York: ACM, 46–54. http://dl.acm.org/citation.cfm?id=2483005.

Schroeter, R., M. Foth, and C. Satchell. 2012. "People, Content, Location: Sweet Spotting Urban Screens for Situated Engagement." In *Proceedings of the 2012 Designing Interactive Systems Conference*. New York: ACM, 146–55. http://dl.acm.org/citation.cfm?id=2317980.

Shampanier, K., N. Mazar, and D. Ariely. 2007. "Zero as a Special Price: The True Value of Free Products." *Marketing Science* 26 (6): 742–57.

Sharp, R., and K. Rehman, 2005. "The 2005 UbiApp Workshop: What Makes Good Application-Led Research?" *IEEE Pervasive Computing* 4 (3): 80–2.

Taylor, N., and K. Cheverst. 2012. "Supporting Community Awareness With Interactive Displays." *IEEE Computer* 45 (5): 26–32.

Taylor, N., J. Marshall, A. Blum-Ross, J. Mills, J. Rogers, P. Egglestone, D.M. Frohlich, P. Wright, and P. Olivier. 2012. "Viewpoint: Empowering Communities With Situated Voting Devices." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, eds. J.A. Konstan, E. H. Chi, and K. Hook. New York: ACM, 1361–70. http://dl.acm.org/citation.cfm?doid=2207676.2208594.

Valkanova, N., W. Robert, A. Vande Moere, and J. Müller. 2014. "MyPosition: Sparking Civic Discourse by a Public Interactive Poll Visualization." In *Proceedings of the 17th ACM Conference on Computer Supported Cooperative Work & Social Computing*. New York: ACM, 1323–32. http://dl.acm.org/citation.cfm?id=2531639.

van Ingen, E., and R. Bekkers. 2013. "Generalized Trust Through Civic Engagement? Evidence From Five National Panel Studies." *Political Psychology* DOI: 10.1111/pops.12105. http://onlinelibrary.wiley.com/doi/10.1111/pops.12105/abstract.

Ylipulli, J., T. Suopajärvi, T. Ojala, V. Kostakos, and H. Kukka. 2014. "Municipal WiFi and Interactive Displays: Appropriation of New Technologies in Public Urban Spaces." *Technological Forecasting and Social Change* 89: 145–60.