Toward Meaningful Engagement with Pervasive Displays

What are the various obstacles to sustained and meaningful participation with public displays? The authors discuss several case studies to frame and address four main challenges: interaction blindness, motives for participation, input modalities, and the ability to find applications on displays.

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While working to understand the difficulties and opportunities of building public display applications, we've identified four key challenges in eliciting sustained and meaningful user engagement—that is, engagement that doesn't consist solely of playing games or "killing time" in other assorted ways. We're interested in interactive sessions that have a more clearly pronounced end goal, such as providing feedback to local government, learning about local history, or finding a specific location in the city. Yet we've found that interaction blindness, a lack of motivation to participate, certain input modalities, and hard-to-find applications can serve as obstacles to meaningful engagement.

In particular, we report on our experiences with the UBI-hotspot infrastructure in Oulu, Finland. The infrastructure comprises several large, multipurpose interactive public displays, deployed downtown and in other high-profile public areas and offering several services to users.[1] We complement the findings from many of our previously published works with additional commentary on the lessons learned during the six years of infrastructure development (from late 2009 to late 2015—see Figure 1) and through cooperation with local citizens and the scientific community. We also mention unpublished probes and tests that add to our discussion on enabling sustained and meaningful engagement.

Networked Pervasive Displays

Academic literature paints a highly optimistic, societally beneficial picture of the future of networked pervasive displays. Interactive screens in our everyday environments aim to introduce play and creativity in cities, fueling the next wave of social change and offering personally meaningful (personalized) content to individual users.[1,2] To this end, several projects have demonstrated the usefulness of public displays across a wide range of noncommercial application domains.

For example, large multidisciplinary efforts aimed at introducing such displays as shared infrastructure for everyone to use outside laboratory environments have been undertaken. In addition to the UBI-hotspots in Oulu, another notable contribution is the e-Campus display network in Lancaster, UK.[3] Both have contributed to a better understanding of the brutal practicalities involved in creating such shared pervasive infrastructures.

On the application level, Nemanja Memarovic and his colleagues have explored the

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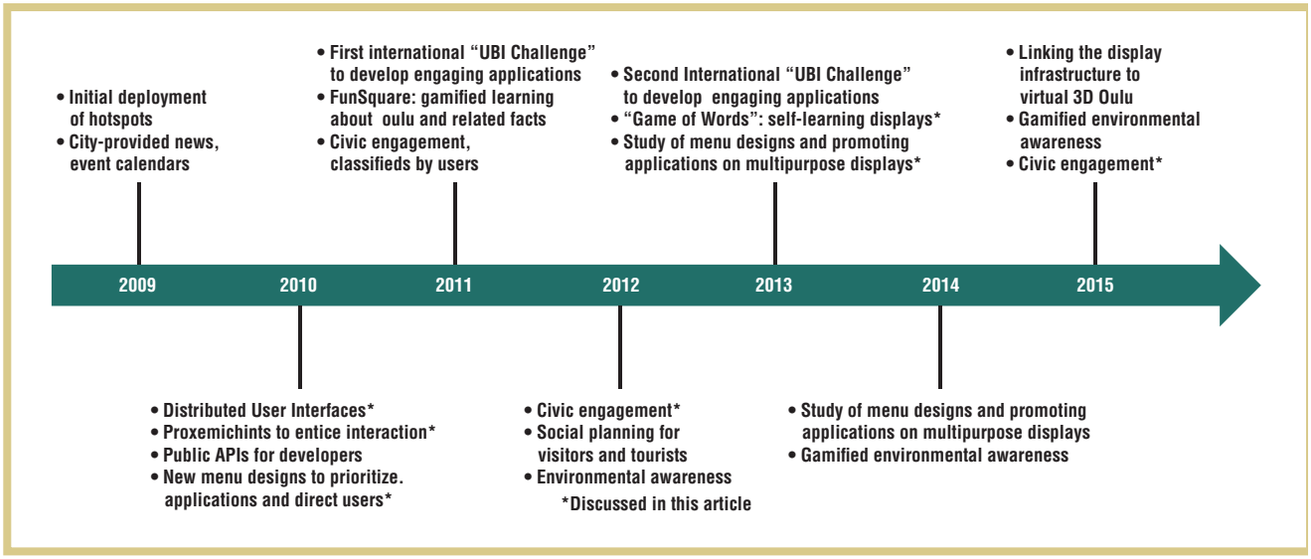

Figure 1. Timeline of related developments and projects on our public display infrastructure, the UBI-hotspot in the city of Oulu, Finland.

complicated challenges that arise when using displays to engage audiences in the wild.[4] Among other issues, they highlight how expectations set by modern smartphones might cause users to perceive public displays as "already obsolete." Mara Balestrini and her colleagues also provide guidelines and discuss the challenges of deployments aiming for sustained community engagement in the wild.[5] They highlight the importance of using technologies with which users are already familiar and of including key community members in projects early on. The same community champions can then help in sustaining the deployments once researchers eventually step down.[6]

Although networked displays are proliferating and new use cases continue to emerge, they are still perceived as novel by users. In a position paper, two of us (Hosio and Goncalves), along with some of our other colleagues, discussed the significance of carefully considering the added value that a public display offers to the organization in charge of physically hosting the displays—an often overlooked yet critical stakeholder.[7] An important step in supporting the organization is ensuring users can find and use available applications and subsequently discover personal value beyond the novelty of the display.

Challenges to Engagement with Public Displays

Sustaining meaningful participation with public displays involves several key challenges.

Interaction Blindness

The first key challenge is interaction blindness—that is, users being unaware of a display's interactive capabilities, and implicitly assuming that it is a simple broadcasting medium. Generic findings on this phenomenon,[1] as well as specific studies,[8] highlight how interaction blindness is a fundamental challenge to tackle in the development cycle of longitudinal public display installations.

The design of interactive public display studies usually begins with an application or service that is deployed on a display. Researchers often implicitly assume that users have already discovered the display in question, inferred that the display is interactive, and become motivated enough to approach and touch the screen. However, these steps prior to the user committing to interaction are nontrivial and shouldn't be taken for granted. They entail major challenges, including making passers-by aware of the interactive affordances of the display, and enticing them to approach the device and begin interaction, overcoming the so-called "first click" problem.

This problem breaks down into three separate challenges. First, potential users must notice the display. This is far from trivial, as the commercial stigma of public displays cause many to ignore them ("display blindness"[9]), and in a cluttered environment, such as a city center, multitudes of visual stimuli compete for attention.

Second, potential users must be made to understand that the display in question is interactive. Although interactive information kiosks and screens are becoming quite common in various spaces, such as shopping malls, train stations, or airports, most displays in public spaces are still used for passive one-way broadcasting of commercial or noncommercial information. Making the distinction between interactive and passive displays can be difficult, especially if both types exist in a shared space, and special care must be taken to ensure that users can easily tell the two apart.

Third, potential users must be persuaded to become active users. Even if the first two barriers to interaction are

overcome, a person might still choose to pass by a display without interacting with it. Therefore, the display must be able to communicate that it possesses something of value to the potential user. This might vary from useful information to ways of killing time, depending on the context and the user's current needs.

Interaction blindness was a recurring gripe related to the UBI-hotspots, so in 2010, we introduced a "proxemic hint" (a call to action). The purpose was to inform a user in the proximity of a hotspot about its interactivity. When software analyzing the real-time video feed of the overhead camera detected a face looking at the display for a sufficiently long time, an eye-catching animation with "call-to-action" text ("touch me") was shown in the top right corner of the screen. Even so, because our displays transition from full-screen broadcast to split-screen interactive mode at the touch of the screen, we can only speculate on how many potential users have dismissed the displays as simple advertisement screens without giving them a second look.

To better understand this issue, we conducted an experiment[8] to investigate whether certain "atomic" visual elements—such as color, animation, or graphics—can be combined into visual signals that help communicate interactivity to those passing by. We used eight interactive displays in areas such as cafés and restaurants and experimented with the following visual signals: color vs. grayscale; animated vs. static; and icons vs. text. The displays showed these signals on the full screen to entice passersby to interact with the screen and logged all interaction.

Upon analyzing the effectiveness of the different signals, we found that the "colored animated text" signal attracted the most interactions, with the "grayscale static text" signal following just behind. The "grayscale animated icon" signal attracted the least number of interactions, and the "colored animated icon" signal attracted the second least. Overall, signals with text were more effective than signals with icons. Interestingly, in terms of the total number of interactions, there was no clear difference between colored and grayscale variations of the same signals.

It's fair to say that interaction blindness acts as the first barrier to participation for all types of interactive applications on public displays. In a rather telling anecdote, one of the authors was recently getting his hair cut in a salon that had one of the UBI-hotspots not 100 meters from the door, with windows overlooking the display. During the haircut, the topic of UBI-hotspots came up, and the hairdresser was very surprised to hear that the display she has seen outside the shop window for more than five years was actually interactive—she had implicitly assumed they were simple advertisement screens put up by the city or some commercial actor.

Although preliminary and potentially specific to the research environment it was conducted in, our study of signals showed that visual signals can be used to help passersby notice public displays and become motivated enough to approach and begin interaction. However, combining the use of full-screen visual signals and broadcast advertising is an open challenge that requires further research. For instance, the UBI-hotspot infrastructure relies completely—100 percent—on advertising revenue to cover the significant costs of upkeep, including electricity, Internet, insurance, and cleaning. Advertisers who pay for maximum visibility are likely to frown upon the use of visual attractors that would take up screen space and distract potential customers from their ads. These real-world constraints serve to prove that public display research is far from being a simple academic exercise, and a middle ground between commercial interests and academic inquiry must be carefully considered.

Motivating Participation

Once users begin interacting with a display, their intent is often to check what is available by browsing through the applications to find an appealing one, thus exploring the available contents without a clear objective in mind.[10] At this point, it's crucial to effectively engage users, particularly in the context of applications that provide more than a simple entertainment value. For example, in the case of applications that can benefit the local community, altruism can provide adequate motivation, because it appeals to people's desire to help. However, our own previous work has shown that additional motivation should be considered. For instance, we found that including intrinsic psychological motivators (such as enjoyment and sense of community) in the design are an important prerequisite for serious and sustained contributions from users,[11] even when the application's stated purpose is for the common good.

Another effective motivator for sustained user engagement on public displays is gamification, because games in general have been reported as appealing and popular among public display users.[1] Consequently, leveraging some aspects of games can be exploited in designing applications that are beneficial to several stakeholders. For example, the playful design of a civic engagement prototype, called *Ubinion*, masked a "serious" civic engagement application as a fun and playful service.[12] Ubinion demonstrated that public displays can rapidly gather large numbers of societally relevant input from citizens if the design is fun and the display is appropriately located.

Another prototype, FunSquare, was designed as a quiz-game on public displays to enhance sense of community among its users and at the same time educate the players about the city of Oulu, its history, and its culture.[4] FunSquare's lure was based on dynamic facts about the deployment environment itself and on the heavily gamified design that appealed both to children and adults.

Finally, earlier work[13] also demonstrated that gamification, when coupled

with highly situated tasks, can lead to meaningful engagement from users, even when competing with dozens of other services on multipurpose public displays. Here, the output from the game was useful in that it provided us with a ranked dictionary of keywords to characterize the general vicinity around the public displays.

All of these examples highlight how taking extra steps to provide users with a pleasant and enjoyable experience will likely increase interest and sustained engagement. Ultimately, our message is to avoid the assumption that designing societally beneficial applications will always be enough to guarantee this user interest and sustained engagement. Over the years, we have noticed that, by designing for group use and fostering collaboration,[12] we can create "stickier" applications that make users spend more time with them. Thus, motivation is a crucial aspect that many public display applications lack, beyond the inherent value of the application itself. In practice, this can involve simple additions that can make a substantial difference, such as using motivational text and instructions[11] or personalizing the applications for each user.[1]

Establishing a Low Barrier of Use

Balestrini and her colleagues discuss how sustained community engagement often requires using technologies with which the users are already familiar.[5] In our environment, we have always aimed at building applications that are available for everyone and present a low barrier of entry. We have learned that new UBI-hotspot users typically assume all interactions happen using the device's touchscreen. While in most cases this is true, touch is not always optimal or even possible in the public space in which we operate.

Several alternatives to touch interaction have been explored in different public display settings. One of the early studies exploiting mobile phones by Nigel Davies and his colleagues[14] used Bluetooth device names to empower public display audiences to choose content shown on displays of the aforementioned e-Campus infrastructure.[3] Doing so, users weren't required to physically go to the displays and "expose themselves" on the metaphorical stage they represent in the public. Instead, users were empowered by a more private control mechanism, which might be desired in certain physically or socially challenging contexts.

Researchers have also explored a wide array of other smartphone-based I/O mechanisms on public displays. For example, dedicated mobile client applications,[4] SMS, Twitter, mobile email,[11] IP-based publish/subscribe architectures, and point-to-point content uploading and downloading using Bluetooth[1] have all been explored as complementary mechanisms to touch-based interaction.

In our own experiments, we have found these alternative input mechanisms handy, especially when eliciting relevant in-depth input from users. For instance, we've explored the tradeoffs of different input mechanisms for obtaining feedback from the public, such as civic engagement. In deployments where the quality of user contributions is essential, a key challenge is minimizing noise—that is, any type of unorthodox input, including irrelevant and out-of-context comments or simply nonsensical text. To this end, we compared three mechanisms that enable users to provide feedback on public displays: a conventional on-screen soft keyboard, email, and SMS, with the latter two being feasible using modern smartphones.[11] The quality of the SMS-based feedback was very high, but citizens left less feedback with SMS than with the other offered mechanisms, likely because of the financial cost as well as the potential loss of anonymity that occurs when using SMS. Although the price of SMS in our case is not prohibitive (0.07 Euros), there's a great difference between a few cents and free. Also, people associate value with their private data (phone number).

Participants of our study indicated that having multiple optional input channels is preferred to touch-only interaction. In particular, email is handy if users have "much to say." Furthermore, an on-screen keyboard is typically more difficult to use than the user's own personal devices to which they are accustomed and use on a daily basis. So, while providing a touch screen enables anyone to interact with services on the display, and thus makes the display highly accessible and equal for all, in many cases, it's simply not enough. Unlike in simple playful deployments, where just a few clicks are sufficient to "get the job done,"[4,12] in cases where public displays are used for harvesting thoughtful and in-depth input from participants, private and effective means of input alternatives should be considered.

Finally, the interaction (and other technical) capabilities of public displays are often perceived as being subpar in quality.[4] We've repeatedly noticed this with our own infrastructure, and it's an issue of unrealistic user expectations,[3] erroneously calibrated most likely by modern smartphones that feature numerous applications, highly sensitive touch screens, high-definition cameras, excellent connectivity options, and dozens of onboard sensors. Despite this, the physicality of public displays still attracts users by engaging them serendipitously. This can be efficiently leveraged, and we see much promise in exploiting personal devices in conjunction with public displays to create distributed user interfaces. If users are accustomed to their private phones, why not let them use their devices then as the key—a kind of remote controller—to the displays? By letting users broadcast smartphone application content to public displays, users are empowered to exploit public screens for many interesting use cases. We can envision a standardized mechanism that couples users' private devices to public displays to introduce a whole new dimension to future public displays and their applications.

Figure 2. Multipurpose public displays. School children (a) and a group of elderly (b) exploring the services of UBI-hotspots in their authentic deployment environments in the city.

Figure 3. Educating our potential users and engaging the scientific community. (a) During the summers of 2009, 2010, and 2011, we held weekly guided events to inform citizens about the affordances of interactive displays. (b) The kick-off event of the "1st International UBI Challenge" application contest to elicit contributions from the scientific community.

Finding and Using Applications

One of the most promising purposes for public displays is community engagement.[15] While the majority of past public display research projects has focused on a single application deployed on a single display, or a set of displays, there exist several motives for public displays to be multipurpose.[1,7] For example, such displays can implement various monetization models and host several types of applications in an attempt to offer "something for everyone." This in turn directly broadens the audience that the displays can serve (as depicted in Figure 2). Different approaches to realize this in practice have been trialed, such as personalizing the offered application set using mobile phones,[2] or creating traditional application menus that offer categorized access to applications.[1]

Using our infrastructure, we have studied how an application's placement in a menu affects its popularity and use on public displays. Not surprisingly, giving an application more prominent placement on menus (more visibility) leads to more attention from users.[7] Although this doesn't necessarily lead to serious engagement with the application, it increases the chances of an application being discovered and used by a person simply going through anything available on the display—out of curiosity, for example.[10] Naturally, this happens at the expense of other applications, so applications with more visibility "steal" users from other applications. Therefore, and if necessary, we can manipulate users toward desired services of a display, adjusting at runtime the overall value provided to different involved stakeholders.

Our work has also revealed interesting similarities between how users search for applications on our public displays and how individuals browse the Web. For example, we found that applications that can be launched from the main screen of our displays are significantly more likely to attract attention away from other applications. This reflects prior findings in the context of online browsing, in which how pages are linked affects how they're visited. Landing pages (the equivalent of our main screen) are typically more popular than pages that are one or more clicks away (the equivalent of our application directory). This is also in line with participants' comments suggesting that users trying to kill time are more likely to try the applications that are given a more prominent placement in the menu (shortcut accessible without browsing deeper into menus). Due to these similarities, we have carried out work to model public display usage from an information foraging perspective.[1]

Designing for the Long Term

The challenges we have discussed in this article reflect some of the unexpected challenges that we have encountered in the course of our research. The long-term nature of our display infrastructure has provided a valuable and unique backdrop against which we can consider those challenges. At the same time, in the six years of our deployment, technology has radically changed, and so has the public's perception of our displays.

During the early deployment years (2009–2011), we focused on educating citizens, our potential users, on the new technology and its possibilities (Figure 3a). One of the most eye-opening findings emerging from these "UBI-walks," as we dubbed them, was how positively people of all age groups perceived the technology once they learned more about it. Even the elderly, traditionally a challenging group to engage, found the technology intriguing and a welcome addition to the city. Similarly, school children and teenagers quickly discovered the hotspots as an endless source of entertainment.

After the initial years of exploration and community engagement, we then engaged the scientific community through international application contests (UBI Challenges) in 2011 and 2013 (see Figure 3b). The contests resulted in a number of excellent public display applications, most of which by now have been published in various academic conferences and journals.[4] In hindsight, we feel that these types of open international contests, where participant teams deploy and evaluate their contributions using the public display infrastructure, are highly efficient in conveying the realities of in-the-wild environments to the community—perhaps even more than what is possible by writing academic essays about past experiences.

In our previous work, summarizing the key challenges we faced during the first three years of deployment,[1] we initially focused on the challenges of

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moving beyond laboratory settings, and the associated challenges introduced by the effect of location, social context, and weather. Those challenges were immediately apparent to us due to the radical difference between our lab and the field. However, in the years that have elapsed since then, we've been able to systematically tell apart and study the usage patterns on these public displays in their urban settings with all the associated "messiness" that such deployment environments bring.

The challenges we report here go beyond the methodological challenges of conducting research in-the-wild and question the long-term prospects of interactive public displays and their potential to sustain engagement over longer periods of time. In this sense, we have found that combating interaction blindness is a key first step toward any kind of engagement. Subsequently, we have observed that engagement can be sustained by using appropriate motivational techniques and input modalities, and that these don't necessarily require substantial development effort, but simply careful design.

Public displays are costly to install and maintain.[3,7] They also age quickly because personal technology advances at an accelerated pace. For these reasons, it's important to consider the long-term prospects of public displays, and design for a long-term lifecycle that doesn't require annual hardware updates but rather views these displays as one constant in a personal ecology of smart devices.

The UBI-hotspot infrastructure is now a mature and integral part of the city of Oulu. This, together with the constant flow of new residents and tourists, provides us with a unique chance to explore the displays' discoverability, usability factors, and learnability, and the perceived long-term relevance of the displays as well as their content. While several open challenges remain,[15] the challenges we have identified here are an important starting point for strengthening the long-term potential of public displays and their sustained, meaningful use. P

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