Situated Engagement and Virtual Services in a Smart City

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In the northern city of Oulu, Finland, we have been pursuing a visible change to the local society by building a functional prototype of what we call an open ubiquitous city. Today the ubiquitous city offers various permanent services as well as short-term research probes for its dwellers to use. In this article we first describe the still fermenting vision behind much of the service development in Oulu. Second, we introduce three new technological concepts that we are currently investigating in the smart city context: situated kiosks for community engagement, sound-based resource discovery mechanism, and a complete, functional 3d-model of the pivotal downtown areas of Oulu. Finally, we discuss some of the future research directions and implications of the introduced technological additions. We hope the ideas shared in this article can help the research community in designing and creating better services for the future cities.

Smart cities, situated technologies, public displays, resource discovery, 3D model, citizen participation, civic engagement

I. INTRODUCTION

What exactly constitutes a smart city? A single dominant answer to the question does not exist [5]. “Smartness” is an ambiguous term, and different institutions and academics have their own understanding of its meaning in the context of modern cities [14]. Common to many viewpoints is, however, that a smart city includes various computational resources deployed in our everyday environments. The true potential of pervasive computing technologies deployed in current and future cities remains still relatively unexplored, despite the steadily increasing interest in many urban planning and academic communities. Different disciplines tend to derive different visions of how this potential may be realized. Caragliu, Bo and Nijkamp note that the addition of pervasive computational resources in our environments highlights the ever increasing importance of information & communication technologies (ICTs) in social and environmental capital of cities [1]. Ishida, on the other hand, argues it is a step towards a more technology-laden connected community that utilizes high-speed networks, flexible service-oriented computing infrastructure and new innovative services to provide added value to citizens and visitors alike [9].

In our work, we take the stance that pervasive computing technologies in cities should be built primarily for human inhabitants, and therefore the humans and their contributions are the focus of our interest [7]. In particular, our overarching goal over the years has been to develop a systematic understanding of how humans – the city dwellers – can interact with their everyday surroundings and provide value to the entire community. We are interested in uncovering the ways they appropriate the offered technology and services. This approach may be in contrast to the more dominant “engineering” approach, where intelligent infrastructure ubiquitously collects without the inhabitants necessarily even realising it. Ultimately, we think that both approaches are necessary for progress.

In this paper, we introduce our approach to making an impact to the local community in Oulu, Finland, by deploying new types of computational resources to the city. In particular we present three new concepts being trialled with the citizens: situated technologies, sound-based discovery mechanisms, and a virtual model of the pivotal areas of the city. First, however, let us briefly introduce the history behind this technology push in Oulu.

II. CASE OULU: OPEN URBAN SERVICE NETWORK

In Oulu, our motivation from the beginning has been to study human activities in the city by deploying technologies as permanent additions in the city fabric, to form the “Open Urban Service Network” (OUSN) [16]. The three cornerstones of OUSN are public open wireless networks, a grid of large (57”, 62”) interactive public displays (Figure 1) [15], and open middleware components and APIs for developers to create new smart city services on top of our offered infrastructure.

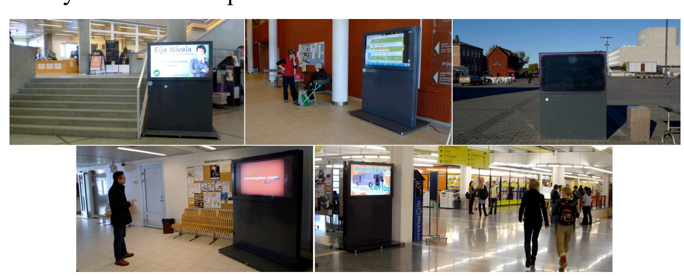

Figure 1. Examples of hotspots in public spaces in Oulu.

Our vision is that from the user community’s point of view, Oulu appears as a smart urban space providing rich interaction between physical, virtual and social spaces. From the R&D community's point of view, the city appears as an open community test-bed stimulating research, innovation and development of new services and applications. The test-bed enables urban computing research in an authentic urban setting with real users and with sufficient scale and time span. Such studies are not always the easiest to run but are increasingly important, because real world systems are always highly situated, and cannot be reliably evaluated with lab studies [17].

Lately, in the spirit of creating new experiences and services for the citizens in the urban setting, we have started to expand the network of public displays with smaller "kiosks" in selected locations. In addition, we are investigating a new sound-based mechanism to discover such situated resources in the environment. Finally, we are in the process of fusing selected already existing real world services into a functional virtual Oulu3D model online. These three ventures are described next.

A. Situated engagement using tablet-sized public displays

Public displays are envisioned to fuel the next big wave of social services in the smart city [11]. While the backbone of public display research in Oulu has always been the hotspot infrastructure [15], depicted in figure 1, we have recently started to explore the utility of smaller public displays as well (see Figure 2). Smaller screen real estate allows for more personal, private engagement with technology. On the other hand, with such screens we are still able to leverage the benefits of situated technologies: The displays are capable of quickly attracting users on their own, without advertising, and people often start using them serendipitously without any special motivation [13].

Figure 2. A small public display kiosk next to a public library entrance.

In our smart city ideology citizens are not just passive producers of data. Therefore, the first concrete experiment with this new infrastructure explored crowdsourcing [8]. In other words, we wanted to actively include the citizens in our deployments, and provide clear value to them. In this case, we used monetary incentives in exchange for labor. We created the globally first situated crowdsourcing platform that follows a market model. Over a period of three weeks, our deployment of just 4 screens attracted 194 unique workers who created accounts and completed 75229 tasks. A clear majority of the participating citizens had no prior experience with participating in traditional online crowdsourcing. This highlights one of the unique characteristics of situated technologies, i.e. their capability to reach otherwise hard to reach populations. Further, our participants indicated being very happy with the introduction of the platform, and the work output quantity and quality was comparable to that of traditional online labor markets. The first trial, reported in [8], was largely onsidered a success, and we are currently creating more tasks and use cases for the developed, reusable crowdsourcing platform.

B. Discovering situated technologies using sound-based watermarks

One of the identified problems with situated technologies, such as displays, is *association*, i.e. leasing it to an identified user [10]. Our previous approaches to this have included e.g. the use of RFID and Bluetooth in conjunction with users' personal mobile phones [15]. Currently, to allow users easily discover and have a temporary ownership of situated resources in our city environment we are exploring the use of *audio signatures*. The system that enables this in Oulu, called SONDI [12], allows mobile clients to serendipitously encounter fixed smart devices in the environment and proactively propose associating the resources to user's mobile devices. The basic premise of the system is as follow: A fixed device broadcasts a unique audio signature to its vicinity on a frequency inaudible to the human ear using a directed speaker. The mobile client listens to these signatures, and when a signature is detected, we can determine that the user is *a)* close enough to a device for pairing; and, since we're using a directed speaker, *b)* the user is in front of the device, as opposed to being *e.g.* behind it. The position of the user is important in cases such as public displays, which naturally are only useable if the user can see the screen. Such positioning is difficult to realize with undirected signals such as Bluetooth. After the mobile client recognizes a signature, the user is notified via tactile or audio feedback that a device supporting pairing is close by, and the user can then decide whether or not s/he wants to go ahead with the pairing.

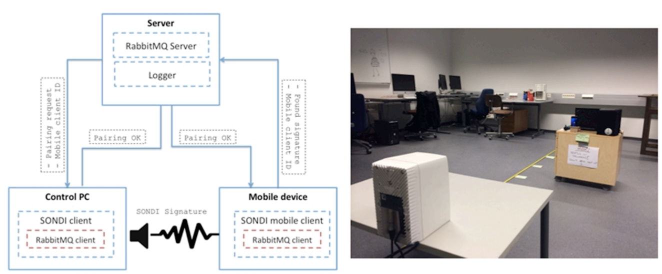

Figure 3. Left: the basic operating principle of SONDI, right: performance testing in a laboratory environment.

Such "pairing" alone is of course a very ambiguous concept. The purpose is to be able to use people's personal mobile phones as keys to the smart environment and its resources. Years ago we attempted to create this kind of system, but the time was not right yet – people found the overall concept too cumbersome and difficult to understand. Now, when the smart phone is truly a ubiquitous resource, we feel it is time to revisit the idea.

C. *Virtualizing the city*

We have recently launched the first version of Oulu3Dlive (Figure 4): an open virtual 3D model of downtown Oulu. For the first version, 9 blocks in downtown oulu and selected indoor spaces were laser-scanned. The model is implemented atop the open source realXtend platform for the 3D Internet (http://realxtend.org/). The environment is not yet open to general public, and we are currently in the process of creating services and content for it. The maintenance, operating principles and licensing of the environment are all handled in cooperation with various key stakeholders. Much like with our hotspots, the overarching vision is to be able to host both commercial and non-commercial services inside the environment, openly for everyone to use. The first version of the model has been so far utilized in various ways, including pervasive gaming, mobile augmented reality, urban planning and the development of the realXtend platform. While the use has naturally so far been for research purposes, we believe that the business cases for the environment will start to emerge soon after the model is opened for everyone to create, explore and utilise.

Figure 4. The Oulu3D model enables urban planning, gaming, virtual services, arts and more online.

III. Discussion

Many cities claim to be “smart” in a rather self-congratulatory fashion [5]. After all, why would a city call itself something else than a smart one? How a city labels itself is irrelevant for obvious reasons. What matters is how a city continually aims to develop itself to better serve its citizens. Citizens make a city. In this spirit, Coe et al. argue that a progressive smart community should offer opportunities for citizen engagement – it should let citizens voice their opinions on what kind of an environment they would like to live in [2]. This is a statement easy to agree with, and one we also suggest to follow when developing or even painting the visions of smarter environments. After all, who else than citizens can know what makes their environment better? It also means that we need to always consider humans as the “customer” of our business of creating a smarter city – even if we are doing "just" research. We must provide value to citizens first, and only after that to ourselves and to the research community.

Although we have previously expressed concerns over the fact that e.g. public display research does not seem to be able to produce long-lasting deployments that provide high value to citizens [6], we still see situated deployments as a good way to reach especially to local communities [4]. The deployments just need to be carefully tailored to their deployment contexts, which is unfortunately far from trivial to execute when attempting to augment the whole city at once, or to somehow magically make it smart overnight. One suggested approach is to create situated systems that, over time, automatically learn about their deployment settings, e.g. in [3], and adapt their service offerings accordingly. While it sounds like a far-fetched scenario, also the current approach of manually tailoring technologies to perfectly fit to their deployment contexts is expensive and does not scale when considering city-wide installations.

Finally, a fundamental challenge of all city-wide installations is the amount of planning they demand beforehand. Research literature often fails to appreciate the amount of work that even a single permanent technological construct in the city requires [6]. Related to this, we hope that our approach of ultra high-definition laser-scanning and virtualization of the city downtown can help in testing and evaluating new concepts, services and even art installations online, before committing to investing more resources to make them happen in the physical world. By virtualisation, we are able to sense e.g. traffic flows in the real world using sensors, project the data online, and then explore the virtual model to find optimal deployment locations in spaces that have suitable amount of users and are both visually and architecturally fit for the planned deployments. In addition, we are able to introduce the planned concepts to selected focus groups of citizens already at this point, before the physical realization of any expensive constructs.

As a final note we wish to bring forth that developing smart cities has indeed matured far from being an engineering subject. Creating computational resources and introducing bandwidth in places where they did not previously exist is simply not enough, but people must be educated and encouraged to take action and start exploring the new possibilities. Therefore, the main take away from this short report should not be the few examples of technical increments, but what they are built for and especially who they are built for. The smart city research community must aim to create deployments for humans first, and certainly not for the sake of novelty. Novelty should never be pursued at the expense of genuine functionality. Only by doing so the actual perceived value of the smart city towards its citizens arises, and technology, people, and the city can meet in a way where the engineering efforts merely work to enhance the human experience of the smart city.

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