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Municipal WiFi and interactive displays: Appropriation of new technologies in public urban spaces

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ABSTRACT

This study focuses on the appropriation process of two public computing infrastructures in the City of Oulu, Finland, a municipal WiFi network and large interactive displays. We analyze the adoption of these technologies in public urban places with a conceptual technology appropriation model involving three layers of factors contributing to the adoption or rejection of a technology. Quantitative data shows that while the use of the WiFi network has grown steadily, the use of the displays has been declining. Qualitative data obtained with ethnographic methods reveals that the adoption of the displays is hampered by their questionable utility and people's apprehension about interacting with the displays in a public social setting. Finally, we identify issues that designers should take into account when deploying these technologies in urban spaces in the future.

1. Introduction

Oulu is a city of about 191.000 people in northern Finland, just 200 km south of the Arctic Circle. Downtown Oulu has been transformed into a civic laboratory [1], where different types of computing infrastructure have been deployed and adapted to provide novel applications and services to people. The civic laboratory dubbed Open UBI Oulu is a joint initiative of local academia (the University of Oulu) and municipal government (the City of Oulu), each motivated by their respective complementary objectives to enhance people's everyday lives and interaction between the city and its residents. In this article we explore the appropriation of two public infrastructures: the *panOULU WLAN* (Fig. 1(a–b)), a municipal WiFi network providing open, free and unrestricted wireless Internet access; and the *UBI-hotspots* (Fig. 1(c)), a network of large interactive displays providing a wide range of information services. Although the "official" given name of the displays is "UBI-hotspots", in this article, for clarity, we refer to them as "displays" from now on, to avoid confusion with the term hotspot often used in the WiFi context.

Appropriation refers to an approach in social science technology studies that strives to explain the adoption of new technologies as a part of everyday life. The two infrastructures, the panOULU WLAN and the displays, were selected for this study, because they are relatively rare as municipal infrastructures, have been publicly available for several years, and are used by a significant number of people. Further, the contrasting characteristics of the two technologies under examination provide an intriguing starting premise for the study. For example, while the panOULU WLAN is practically invisible and its usage is not tied to a certain fixed device or to a certain place, the displays are very visible, situated and their usage can be compared to public performance. We base our exploration on two complementary datasets. First, our quantitative data comprises a two-year usage log of the infrastructures and a questionnaire study of local university and high school students on their perception and usage of the infrastructures.

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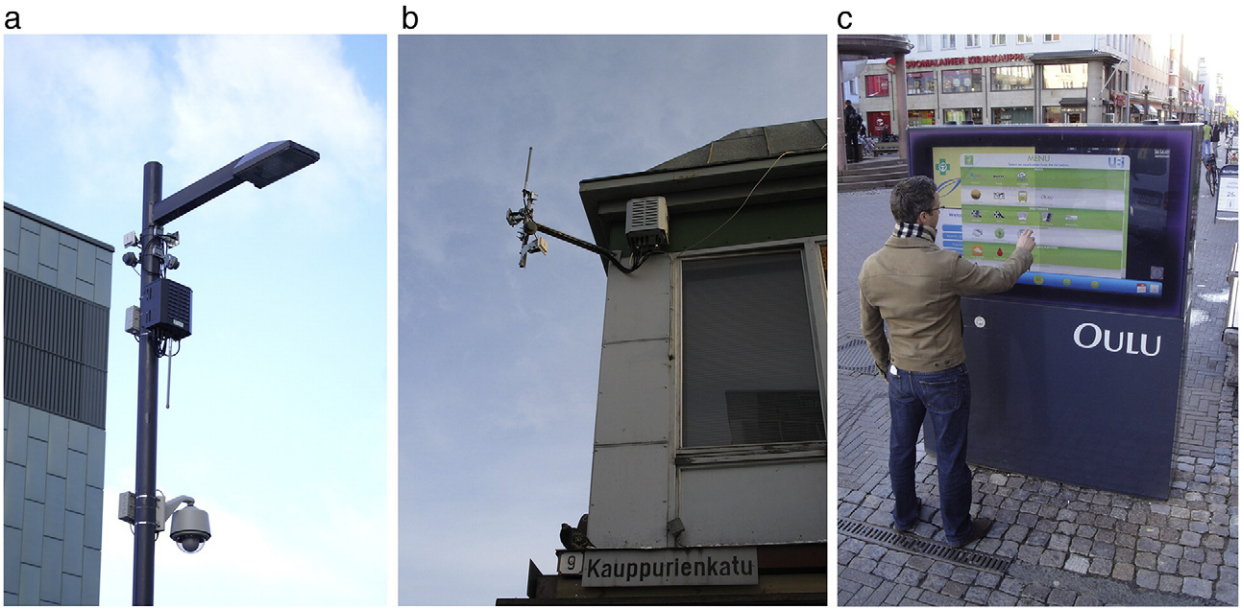

Fig. 1. (a–b) panOULU WLAN access points; (c) Outdoor UBI-display.

Second, using ethnographic methods we have collected qualitative data which enable us to explain and understand why people have (not) used the infrastructures in particular ways. While the quantitative data provides an overview of long-term usage trends, complementing it with ethnographic material offers a deeper insight into the data and raises an opportunity to perform "thick description" [2] of people's narrations of their urban practices related to technology. For this purpose we develop a technology appropriation model derived from an existing appropriation model. We take especially into account people's behavior in urban public spaces; through this analysis we scrutinize why the trends in the quantitative usage of these two infrastructures differ so remarkably. Lastly, based on these findings, we identify issues that designers should address when deploying new technologies in urban spaces in the future.

2. Ubiquitous computing and smart cities

The civic laboratory dubbed Open UBI Oulu is driven by two related paradigms, ubiquitous computing and smart cities. The "ubiquitous computing" (ubicomp from now on, [3]) paradigm has been driven by a vision of an omnipresent technology-rich space providing intuitive, unobtrusive and distraction-free interaction. In this kind of urban surroundings computers are regarded as secondary "invisible" artifacts, embedded into the physical environment and operating in the background. The set of physical objects in which computing resources are embedded are understood as the primary artifacts, the "interface". The study of ubicomp in urban spaces is referred to as "urban computing" which is an emerging multidisciplinary field considering public places such as cities and parks as sites for computing, including interaction between humans and such environments [4].

Despite the substantial investment by government and industry in ubicomp research during the past 20 years, few lasting contributions to the urban digital fabric have emerged. This lack of coherent progress has triggered critical discussions on how ubicomp research is being conducted. Most ubicomp research is still conducted in labs, due to the high cost and efforts involved in setting up (and maintaining) similar real world installations for real people. Even though ubicomp system studies dubbed as "in the wild" are increasing, they are still predominantly short-term and small-scale, thus failing to establish the critical mass of real users needed for the rigorous evaluation of a system as (un)successful [9]. Further, these studies are hampered by theoretical and methodological gaps. First, there is no fundamental theory for designing and building ubicomp systems as integral elements of urban landscape [10]. Second, the unsuccessful porting of existing interaction theories developed in labs into real world suggests that there is no solid theoretical basis that would unambiguously explain "wild practices" [11]. Third, we do not have rigorous metrics for evaluating ubicomp systems in real-world settings. To address these gaps, we need a much wider access to large-scale, city-wide ubicomp installations, in order to significantly advance our understanding of the design, practices, and evaluation of smart city applications.

In the latter half of the 2000's the ubicomp paradigm became prominent as a technology-driven realization of the "*smart city*" concept, most notably in the U-Korea initiative [5]. Cities are increasingly looking at ICT to reduce costs, to become more efficient, and to deliver the quality of life citizens expect while balancing budgets. Accelerated by the digitalization and miniaturization of electronics and the explosion of communication networks, new ICT technologies have pervaded the society in many ways. The convergence of smaller, cheaper and faster computers and ubiquitous communication technologies have made it easier to control systems and to empower people to make cities smarter. However, empowering people cannot be taken for granted but people's role in the design process needs to be carefully discussed and explored. People play a pivotal role in cities becoming "smarter". This raises several important questions that need to be carefully considered when designing

services for such smart cities. These include: What information should be offered and received?; When and how should this information be delivered?; What reactions can be expected?; and How can ubiquitous computing systems respond to these needs [12]?

The term "smart city" remains vague and ambiguous, despite the concept's increasing popularity in academic and urban planning communities. No widely accepted definition for a "smart city" exists, and different disciplines impose different interpretations of this vision. In some cases, the smart city is understood as a strategic device to encompass modern urban production factors in a common framework and to highlight the growing importance of ICT and social and environmental capital in profiling the social competitiveness of cities [6]. Others understand it as a more technology-laden connected community utilizing ubiquitous high-speed networks, a flexible service-oriented computing infrastructure based on open industry standards and new innovative services to provide added value to citizens and visitors alike [7]. Especially our understanding of the impact of smart cities on people's daily lives is much less refined although mobile and personal devices have been the center of attention for several years [8]. Through a critical scrutiny of these environments we hope to answer the following questions: Are "smart cities" truly smart for everybody? Do the available services and information meet the vast diversity of city dwellers and their practices? How do the dynamics of urban space affect the use of (public) technology?

To explore these questions via a longitudinal large-scale study in a real world setting, the University of Oulu has during the past ten years invested, together with the City of Oulu, several million euros into ubicomp infrastructure deployed around downtown Oulu. The resulting Open UBI Oulu test-bed is arguably the most versatile civic laboratory in the world where researchers have such a strong administrative and technical position [13]. The test-bed facilitates longitudinal provisioning of a wide range of novel services to the general public in an authentic urban setting, establishing the necessary critical mass of real users. The services are regarded as "urban probes", probing urban space and its inhabitants [14]. By monitoring the usage of the services and people's interaction with them, we obtain high quality research data on human–city interaction, generated by real people using infrastructure and services on their own out of their own will. Deploying novel technologies in a real environment enables us to reflect on how people experience these technologies as part of their everyday lives. Thus, the data differs substantially from material collected by typical lab studies with recruited test users [15]. Of course, we cannot erase our accountability and agency: our civic laboratory is built under certain conditions with certain goals, aims and (political) strategies in mind [16]. Thus, it is not by any means free from all bias.

3. Theory — appropriation of new technologies in urban space

3.1. Technology appropriation

We consider the adoption of new technologies as a process of *appropriation* where people negotiate individually and with others on how to adopt new technology [33]. Users' active role is thus emphasized, but the appropriation approach is neither socially nor technically deterministic. Rather, it is a pragmatic micro-level approach trying to explain how people make sense of new technologies [34]. Technology and society are molded in a reciprocal relationship; when adapted and integrated into daily practices, technologies can shape the usage environment and the user. The methods we used for collecting research material relate well with the appropriation approach; the quantitative data shows broader usage trends, i.e. how largely a technology is appropriated, and qualitative, in-depth material has the potential to reveal the micro-level dynamics of appropriation; for example, what factors support or hamper the usage of a technology.

Thus, appropriation entails people's constantly participating in the molding of technologies by giving meaning to them and integrating them into their everyday lives, social relationships and values. This is not a straightforward or finite process but rather a continuous negotiation tied to people's needs and changing conditions. The process of appropriation is also tightly connected to people's previous experience of ICT and other technologies. Green and Haddon [35] argued that technologies can be "re-domesticated" or even "de-domesticated": people can give up technologies that do not serve them anymore. Especially in Scandinavia the appropriation framework has been developed to understand the adoption of technology in Western households; due to this it has been called 'domestication' [36]. The novelty of our approach lies in applying the appropriation framework in a technologically augmented *urban environment*. We prefer the concept of 'appropriation' as the concept of domesticity refers to processes taking place at people's homes; the dynamics of public places are fundamentally different.

The appropriation of municipal and community WiFi networks has typically been explored via ethnographic studies of the users of WiFi hotspots, which have highlighted spatial, temporal and social variations in the usage practices. For example, Forlano [67] found individual WiFi hotspots to establish so-called "third places", in addition to office and home, where people go to conduct both work and leisure related activities facilitated by the Internet connectivity of a WiFi hotspot, so that the selection of the hotspot is dictated by transportation options and life rhythm. Afanasyev et al. [66] reported a quantitative usage analysis of a large urban WiFi network, confirming the spatial and temporal patterns. The mismatch between the affordance metaphors announced for a municipal WiFi network and the actual affordances experienced by the users of the network has been identified as a fundamental challenge for their adoption [68,69]. Many municipalities have advertised their WiFi network as a public utility providing unlimited ubiquitous Internet access anywhere and anytime, when the users experience the network as a set of disjoint hotspots compounded with accessibility issues such as intermittent connectivity, low bandwidth, blocking of particular applications, hidden price tags, and need for user accounts and dedicated hardware.

Past research on the appropriation of public displays in urban spaces has in most cases been conducted as short-term small-scale studies with a single display offering a single and often artificial service or content. Nevertheless, they have identified the now well-known generic challenges in the adoption of public displays: the enticement of interaction (e.g. [70]), display blindness (e.g. [55]) and the coupling of displays with mobile devices into hybrid interfaces (e.g. [71]). The

long-term deployment of the Wray Photo Display in a rural village in England exposed the need to create technologies that would allow people and communities to utilize interactive displays with the ease of traditional noticeboards [72].

3.2. Our technology appropriation model

Our technology appropriation model is derived from the model originally introduced by Carroll et al. [63] and shown in Fig. 2. Carroll et al. developed their model to "describe some of the factors that attract young people to mobile technologies"; it "builds a theory about the process by which young people adopt and shape mobile technologies according to their needs." Their aim was similar to ours in the sense that they strived to *understand* people's long-term use of technologies, and they also used the qualitative, micro-level approach. Technology-as-designed usually offers possibilities and constraints to its potential users; however, appropriation is a series of negotiations where different factors determinate the outcome, and there is no linear track between the design, adoption, use, and impact of technology [64]. In their study concerning mobile technologies Carroll et al. identified three sets of factors that come into play at different stages of the appropriation process and that resulted in either non-appropriation, disappropriation or appropriation of the proposed technology. These factors are 1) attractors/repellents that function like a filter that can lead to immediate rejection of the technology or to the beginning of the appropriation process; 2) appropriation/disappropriation criteria, which refers to the phase where users test and negotiate with the technology; 3) and finally higher order reinforcers that ultimately decide the faith of the technology. We have developed the model based on our findings.

Our *appropriation model of public technology in urban space* is shown in Fig. 3. The different appropriation levels are extracted from our material; nevertheless, some factors are similar to the model of Carroll et al., for example the unfamiliarity/familiarity of technology. The level 1 factors work as a filter that can lead to never adopting the technology, i.e. non-appropriation. At level 2 people are already actively "testing" the technology which can lead to appropriation or disappropriation. Level 3 refers to the larger sociocultural factors that exist throughout the whole appropriation process and can either support it or prevent it. The individual factors are discussed in more detail in sections 5 and 6.

The main modifications to the model of Carroll et al. rise from the anthropological premises of our study and from the public nature of our urban technology. Firstly, when considering the appropriation of new technologies, we cannot neglect *the sociocultural reality* that has fundamental effects, for example, on the attitudes and values of the citizens. Technologies are always adopted in a particular place, time and situation framed by certain social and cultural practices [37]. It is crucial to acknowledge that in our case the new computing infrastructures are deployed in a city that has for three decades determinedly built its high technology industry and image. Indeed, seeking transformation from stagnant conventional heavy industries, the City of Oulu declared itself as a city of technology already in 1984 [38]. This strategy has been successful and it has formed a powerful discourse of the high-tech city which affects all citizens. Instead of "higher order reinforcers" described by Carroll et al. we have added the layer of "higher order factors" to our appropriation model to describe these omnipresent large-scale factors that can either work as reinforcers or repellents. Further, in order to understand the usage of ubiquitous technologies in *public urban* places, we have to consider certain basic principles (social norms) that control people's behavior in such places and can restrict or encourage the utilizing of ubiquitous technology. We present here three aspects that we consider central to our analysis. When evaluating technology use and appropriation in urban space, the first essential viewpoint is whether the interplay between people's actions is considered either *public or private*. This consideration depends on cultural and social contexts, and thus, for example, different generations can understand them differently. This has been discussed especially in the context of mobile phones; for instance, where it is appropriate to talk on a phone [39,40].

The second viewpoint to consider is the concept of *anonymity of people moving around in the city*. This has been a recurrent theme in discussions about modernization and urbanism for

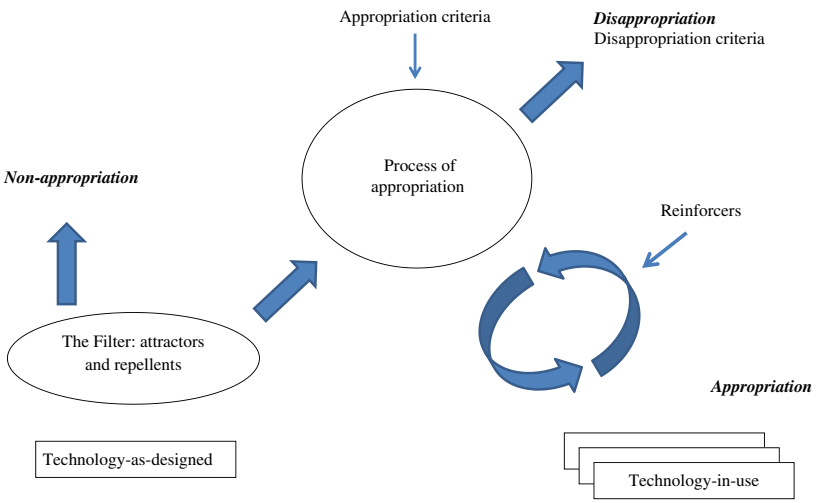

Fig. 2. The technology appropriation model of Carroll et al. [63].

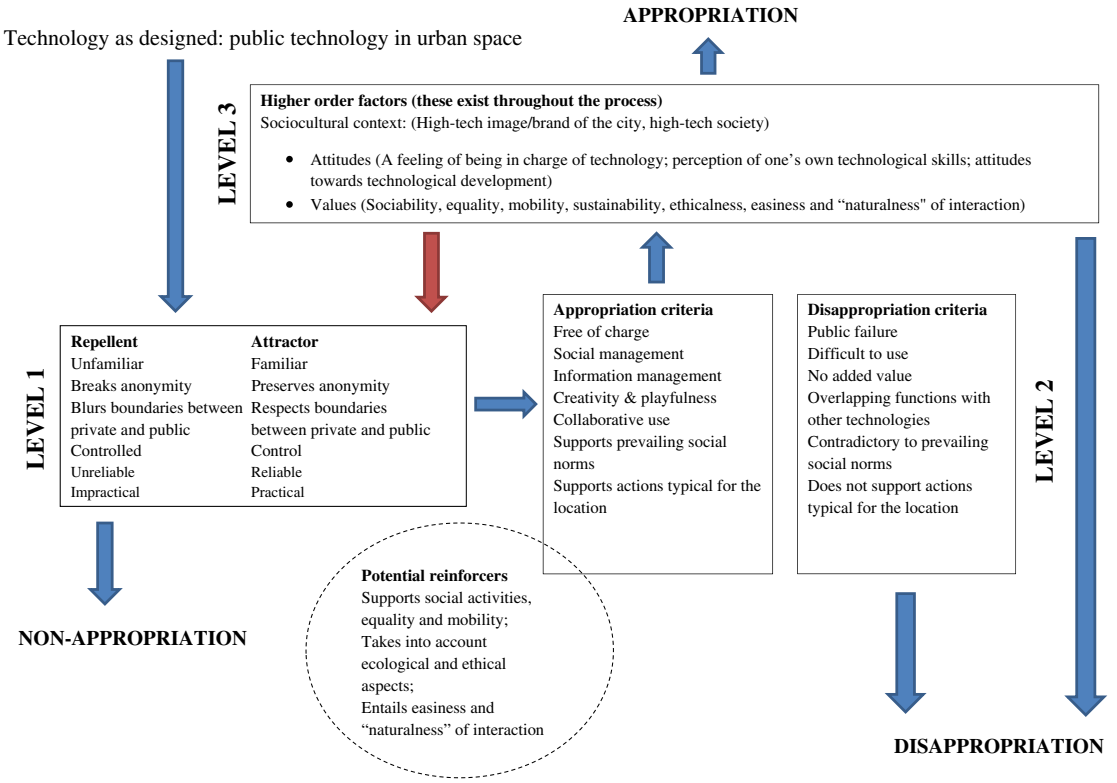

Fig. 3. Our appropriation model of public technology in urban space.

decades [41,42]. It has been described as a *blasé outlook*, an attitude of indifference [43], or *civil inattention* [41]. More recently, Mäenpää [44] has used the concept in a Finnish context. He explains how anonymity becomes a social norm in public space and how it leads to the minimization of open contact, for example verbal or eye contact. This indifference enables the sense of personal space in an otherwise dense environment packed with information and other people. The demand of anonymity determines, at least partially, what kind of actions city dwellers are ready to take in urban space; these are further discussed in our analysis.

The third key concept is *self-expression*. In public places people are aware (consciously and subconsciously) of others and want to give a certain perception of themselves. This can be understood as a performance similar to acting that rules how we appear in the eyes of others [45]. Goffman called this *impression management* [46]. In the social studies of technology, especially portable devices have been studied as objects of self-expression, having plenty of symbolic meaning; for example, in public places they can act as a fashion statements [47]. The use or non-use of certain devices in public can also be interpreted in the light of impression management.

4. Materials and methods

4.1. Infrastructures

Here we only briefly describe the two infrastructures for the sake of brevity. Further technical details are available in related papers provided as references. We also elaborate on the inputs and outputs of the City of Oulu, as they are the owner of the public sphere augmented with these technologies.

4.1.1. panOULU WLAN

The panOULU WLAN (panOULU from now on) is a municipal WiFi network provided jointly by a triple-helix consortium of thirteen organizations: five municipalities, four public research and educational institutions, and four commercial ISPs [17]. The network comprises two fundamental parts, the original 'Oulu City' part founded in 2003 and the more recent regional expansion to eight nearby townships in 2009. The municipalities and public organizations effectively pool their WiFi zones (e.g. the University of Oulu its campus network) into a common network resource, while the ISPs sell so-called panOULU subscriptions that allow any customer to obtain panOULU coverage in its premises. The network currently has ~1440 IEEE 802.11 APs (access points) which relative to the size of the community make it the largest municipal WiFi network in the world to provide open (no registration or authentication), free (no payment) and unrestricted (no limitations) wireless Internet access to the general public. While the connection is provided "as is" without any quality of service assurances, a recent empirical study found out that the end-user quality of service of panOULU compares favorably to that of commercial 3.5G (HSPA, High Speed Packet Access) mobile data networks [18]. Further, the connection is provided without any security mechanisms (e.g. encryption of wireless links) and security assurances. Any service provider desiring authentication,

confidentiality and integrity is expected to provide end-to-end security for that purpose.

"*Open wireless network is a civil right*". This statement by the former CIO of the City of Oulu underlines how the City administration regards panOULU as a municipal infrastructure just like streets and public libraries. panOULU's "business model" is simple: each provider of a WiFi zone is responsible for the expenses and management of its zone according to jointly agreed principles. The City of Oulu sponsors the Internet gateway and the core servers, while the University of Oulu sponsors the maintenance of the core services. In 2011 the operational expenditure funded by Oulu tax payers was 164.000 EUR, spent on AP backhaul and maintenance, Internet gateway and server room facilities. Relatively speaking, this amounted to 1.16 EUR per capita or 1.59 EUR per each unique device using the network in 2011.

4.1.2. UBI-displays

The UBI-displays are large interactive public displays deployed at pivotal indoor and outdoor locations around Oulu. A display consists of a 57 or 65 in high-definition LCD panel with a capacitive touchscreen foil, a control PC, two overhead cameras, a NFC/RFID reader, a loudspeaker, WiFi and Bluetooth access points, and high-speed Internet access [19]. The first twelve displays were deployed for summer 2009, six double-sided displays outdoors along walkways in the heart of the city and in the market area, and six single-sided displays indoors in popular municipal buildings such as the main library, the youth and culture center, and the swimming hall. Additional six indoor displays were deployed in summer 2012. The current 18 displays represent the world's largest deployment of interactive public displays for research purposes in a city center.

In terms of interaction a display is in either passive broadcast (digital signage) or interactive mode. In the passive broadcast mode, the screen is dedicated to the UBI-channel — a customizable playlist of video, animation, and still photographs. When the cameras detect a face or someone touches the screen, the display changes to an interactive mode, where the screen estate is divided between the UBI-channel and a customizable UBI-portal. The portal is realized with the Web paradigm, comprising a set of webpages rendered by the corresponding webserver processes and managed by our in-house screen real estate management system. The services are referenced by their URLs and can reside anywhere on the Internet. Some services involve a personal mobile phone, for example, content upload or download to or from a mobile phone, or coupling the personal mobile phone's user interface with the display's public user interface into a distributed/hybrid user interface [20]. We have used NFC/RFID tags, QR codes, Bluetooth, and SMS to enable the pairing of the mobile phone with the display. Although all services are usable without any authentication or login mechanism, a user can also create a personal account. Upon creating an account, the user can personalize the display and couple the account with his/her Facebook account, allowing the posting of game scores on the Facebook wall, for example.

We have released three distinct versions of the UBI-portal: version 1 in June 2009 [19], version 2 in June 2010, and version 3 in June 2011. The current version 3 contains ~25 distinct interactive services in seven categories: news, services, city, third party, fun & games, multimedia and survey. These services are provided by us, the City of Oulu, private businesses, nongovernmental organizations and creative communities. Some services are available only temporarily. For example, in the summer of 2011, the City of Oulu's Technical Center provided the "Rotuaari Renovation" service that informed the citizens about the major renovation of the Rotuaari walking street area and provided the general public with a channel for giving feedback to the Technical Center. The City of Oulu Communications provides the City pages that among other things contain all official municipal announcements.

Regarding the "business model" of the displays, the University of Oulu has committed to keep them operational until March 2017, which was one of the many conditions of the ERDF (European Regional Development Fund) project funding 89% of the capital investment, with the City of Oulu sponsoring the remaining 11%. To cover the displays' operational expenses, such as Internet access, electricity, cleaning and insurance, we sell the capacity of the UBI-channel and UBI-portal for commercial use.

4.2. Quantitative data

We illustrate the relative usage and adoption of the two infrastructures with trends extracted from usage logs and with excerpts from a questionnaire study of local high school and university students as representatives of the generation born after the general introduction of digital technologies and/or having lived most of their lives with digital technologies.

4.2.1. Usage logs

All usage events in the panOULU (e.g. a device connects to an AP) and on the displays (e.g. a service is launched in the UBI-portal) are logged in a database. However, since both infrastructures can be used without authentication, we are not able to provide any user specific statistics. Fig. 4 shows the linear trends fitted to the selected monthly usage statistics over the two-year period from June 2010 until May 2012. Since the infrastructures were dynamic so that APs or displays were temporarily unavailable due to renovations and new APs were installed over time, the monthly statistics have been normalized with respect to the size of the infrastructure in a particular month, i.e. the number of available APs in panOULU and the number of available screens in the displays.

The message of Fig. 4 is clear: while the usage of panOULU has been growing steadily, the usage of displays has nevertheless been slowly declining. When considering the usage trends, we note two details. First, while the displays were available at exactly twelve spatial locations, panOULU was available at numerous locations, relatively speaking. Second, while a display can typically serve just a single user at any given moment with its single-touch touch screen foil, a single panOULU AP can serve a significant number of devices simultaneously. Therefore, the usage of panOULU per unit of infrastructure can theoretically scale up much better than that of the displays. Nevertheless, neither of these issues alone explains the declining usage of the displays.

The fact that online time has not grown as fast as the number of unique devices in panOULU is due to the evolving device base where the proportion of mobile devices has been increasing at the expense of laptops. Fig. 5 shows the relative

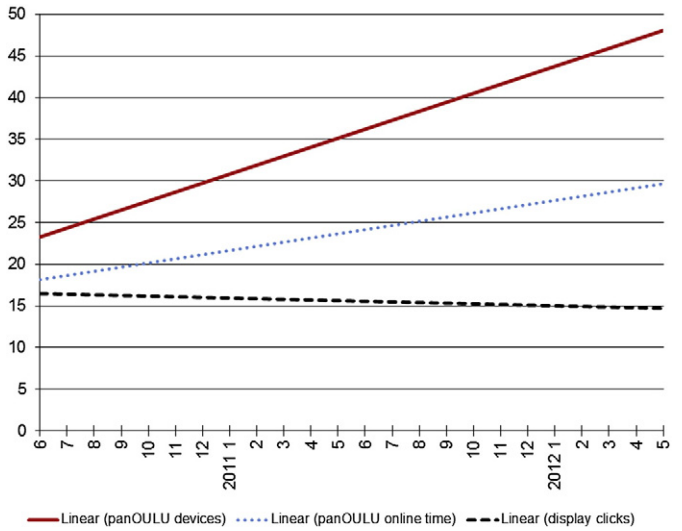

Fig. 4. Linear trends illustrating the evolution of the usage of panOULU and displays. The units of the vertical axis are: number of unique WiFi devices per AP, 1000 min of online time per AP, and 100 clicks per display screen.

proportions of four most popular device manufacturers of all devices using panOULU, as determined from the manufacturer ID of the MAC address of each device. We see that the share of Intel-based laptops dropped from 22.3% in June 2010 to 10.6% in May 2012. The "valleys" in Intel's plot in July reflect how the usage of laptops drops during the summer holiday month. Reflecting global mobile phone market trends, the proportion of Samsung phones grew from 1.0% to 13.6%, whereas Nokia dropped from 31.0% to 24.9%. Apple's share contains laptops, pads and phones, as the devices cannot be distinguished from each other based on their MAC address.

Table 1 shows the usage statistics for all devices and for the devices of the four most popular manufacturers in May 2012. As one particular measure of client mobility, a device is deemed to have a "home AP", if at least 70% of sessions and at least 30% of online time incurs at that particular AP. A mobile session refers to a session during which a user device uses at least three APs of which at least two are 50 m apart. A "heavy user" corresponds to a device that used the network during at least every other day during the month. A "visiting user" corresponds to a device that used the network for at least four days during a period of at most one week in length. Devices not categorized as "heavy users" or "visiting users" are regarded as "casual users". We see that laptops are stationary and accumulate much more online time (a laptop can be connected to panOULU for a whole month) than mobile devices exhibiting a large number of short sessions.

During the 24-month data collection period 32 different services were offered in the UBI-displays and they were launched from the UBI-portal 217,550 times in total. Table 2 shows the share of the 12 most popular services of all launches, including all five games offered during the period. Table 3 shows the ranking of the 12 UBI-displays according to their share of service launches. Toripolliisi and Rotuaari <X> correspond to outdoor displays. We see that the displays located at the swimming hall and the indoor sports arena contributed half of the usage. We have to point out that neither all 32 services nor all 12 displays were necessarily available to the general public during the whole data collection period for various reasons.

4.2.2. Questionnaire studies

The usage and perception of panOULU and displays among local high school and university students were explored with questionnaire studies conducted in May 2012. At the high school, 98 students of 16–19 years of age at four different classes filled in a paper questionnaire after a short introduction of panOULU and the displays. The students of the University of Oulu were invited by email to fill in an online questionnaire that was open for nineteen days and completed by 924 students.

Selected statistics of the questionnaire data shown in Table 4 confirm the fact that panOULU enjoys more widespread adoption and support than the displays among the students. Regarding the limited availability of the displays, a clear majority

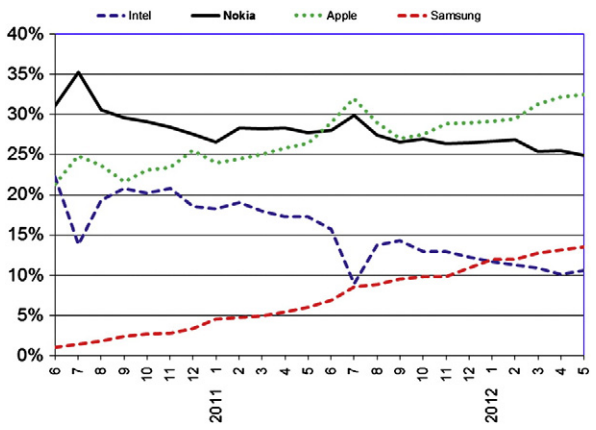

Fig. 5. The relative proportions of four most popular device manufacturers of all devices using panOULU WLAN in a particular month.

Table 1
Device profiles in May 2012.

Attribute		All devices	Manufacturer			
			Apple	Nokia	Samsung	Intel
# Devices		37167	12058	9257	5042	3958
Proportion of all devices (%)		100	32.4	24.9	13.6	10.6
Proportion of devices with "home AP" (%)		70.6	56.8	70.5	68.6	94.8
User type	"Heavy users" (%)	16.3	24.8	12.8	12.0	9.4
	"Visiting users" (%)	57.7	46.5	59.1	60.3	71.8
	"Casual users" (%)	26.0	28.7	28.2	27.7	18.8
Sessions	Average per device	31	51	22	22	15
	Median per device	8	18	6	7	3
	Proportion of mobile sessions (%)	13.1	13.6	15.2	15.1	2.6
Online time	Average per device (min)	647	587	289	325	1475
	Median per device (min)	75	109	27	48	128
	Most active 10% contribute (%)	77	68	76	72	74

of the respondents thought that the current population of displays is sufficient and a minority reported having not been able to use a display because it was occupied. The only clear difference between the two groups of students is in their perception of the usefulness of the displays; university students did not see the displays as very useful. This may be partly explained by the high school students' reported interest in playing the games while university students reported to prefer information services. The perceptions of university students can be explained by looking at the qualitative material that concerns approximately the same age group.

Table 2
The ranking of the 12 most popular services in the UBI-displays.

Rank	Service	Description	Share (%)
1	Hangman	Game	17.4
2	Oulu Today	Current news headlines & weather	14.2
3	UBI Mosquitos	Game	9.5
4	UBI postcard	Photo greeting	6.6
5	City of Oulu	E-government information	4.1
6	Ubitris	Game	3.9
7	Blood service	Information on blood donation	3.8
8	Belle memory	Game	3.3
9	UBI photos	Photo archive	3.0
10	BlueInfo	Mobile information pick-up	3.0
11	Battleship	Game	2.8
12	Kaenkky	Fast food restaurant directory	2.6

Table 3
The ranking of the UBI-displays according to their share of service launches.

Rank	Location	Share (%)
1	Swimming hall	38.9
2	Indoor sports stadium	11.4
3	Toripolliisi	10.6
4	Rotuaari South	6.5
5	Main library	6.1
6	Rotuaari crossing	5.8
7	Rotuaari square	5.0
8	Rotuaari east	4.9
9	Youth and culture house	3.6
10	Rotuaari west	3.1
11	UO campus	2.7
12	OUAS campus	1.4

4.3. Qualitative data

To understand the citizens' everyday ICT practices, we have collected qualitative data from two distinct groups of people living in Oulu, elderly adults and young adults, using traditional ethnographic methods and methods derived from design studies. The research material on young adults' experiences was collected with the *cultural probe methodology* [23,24], i.e. participants of the study performed self-documentation with a diary. Later, they were invited to participate in semi-structured group interviews. Elderly adults were studied by using semi-structured theme interviews.

Williams et al. [25] called for "situated analysis of the urban practice" to unravel essentialist notions of the city and its residents. They argued that urban computing has relied on a generalized conception of "the city" and reduced understanding of the people living in; these have been the points of departure for many urban technology designs. Our in-depth qualitative studies strive to comprehend the diversity of the socio-urban practices of everyday life. Combined with insights offered by quantitative material we can obtain both *broad* and *deep* perceptions on how ubiquitous computing functions in a real environment full of diverse city dwellers, and even more importantly, how we could improve it.

4.3.1. Cultural probe study with young adults

Young adults are often considered the early adopters of new technological innovations. Perhaps, due to this, they often

Table 4
Selected statistics of questionnaire studies of local students.

	High school (n = 98) (%)	University (n = 924) (%)
Have used panOULU	84	89
Think that panOULU should be introduced in other cities	79	79
Have used displays	48	46
Reported not having been able to use a display because it was occupied	4.3	12
Think that there are enough displays in Oulu	78	66
Think that displays are useful	78	28
Think that displays should be introduced in other cities	55	46

represent the typical, if not ideal, resident of the city and user of ubicomp infrastructures in the imagination of the designers [16,26]. "Young, affluent, cosmopolitan and technologically savvy" people are often favored by urban computing designs though this definition is extremely exclusive [25]. Age alone cannot be understood as the only category defining people; in other words, we argue that not all young adults share these attributes. In this light, we found it crucial to critically examine this age group and break down essentialist perceptions attached to it. Studying this particular age group by using both qualitative and quantitative research methods gives us a chance to scrutinize the experiences and conceptions of young adults more profoundly.

The conducted study was based on the *cultural probe methodology*, which relies on self-documentation and aims at uncovering people's personal perspectives and experiences [23,24]. Probes can consist of different kinds of playful and creative tasks that participants are asked to perform, such as filling in diaries, taking photographs or drawing maps. Before planning our cultural probe, we conducted four group discussions with 20 young adults to gain insights into the current ICT reality of the age group. After analyzing these discussions, we designed *a diary* that included ten different tasks. It resembled a small scrapbook; it was meant to be colorful and inviting, and participants could for example draw pictures and add clippings to it. The idea was to draw participants' attention to their own ICT use and make them contemplate everyday life with ICT from different angles and in different places, both in private and in public. After finishing the diary, participants were invited to take part in a group or couple interview to discuss and reflect on these themes.

The cultural probe study involved 48 participants between ages 20 and 30 years. 37 of them were women and eleven men. Participants were recruited mostly through mailing lists of different academies in Oulu. The majority were studying at the University of Oulu or at the Oulu University of Applied Sciences or had already graduated from either of the two universities. Most were still students; a few were working full-time; two were unemployed; one was on maternity leave and one a stay-at-home mother. Participants came from highly different areas of expertise, from communication to industrial engineering and midwifery. Only sixteen participants were originally from Oulu, while 25 had lived in the city for less than five years and four of them even less than a year. This reflects the role of Oulu as the most popular student city in northern Finland which attracts young people, especially from northern Finland and nearby small townships.

4.3.2. Life story interviews of elderly adults

Though gerontechnological studies have shown the need for participatory design which includes the aging and aged adults [27], the understanding of adolescents as the "early adopters" can still affect the technology design practices, especially in projects where the prospective users are "everybody" [28]. Some elderly people may be part of these "early adopters", but mostly their computer literacy is below average. Despite egalitarian aims, public technological novelties may be designed to attract the imagined early adopters to use new devices and applications, thus, constructing a bias in design. Therefore, to grasp an understanding of "real people" in a "real ubicomp environment", it is essential to study different kinds of occupants in this particular public urban space. New ubicomp technologies have the possibility to affect the social organization of space; and if it is designed for younger people, this urban space might feel more and more uncomfortable for the elderly adults [29,16].

In order to look at the city as a place of manifold and heterogeneous people, we also interviewed elderly city dwellers. These interviews were based on the *life story method* [30,31] where narrations are built around interviewees' previous and current experiences on ICT. We discussed, for example, the transition from landline phones to mobile phones, and the consequences of this change; computer and Internet usage; as well as their spatial practices in public places. This method enables us to scrutinize how earlier experiences and personal histories affect interviewees' current ICT usage in private and public, thus, opening up the appropriation as a long term process where, for example, the meanings of different technologies are connected to each other.

The elderly interviewees were recruited from a computer course for aging citizens held at a community center. During the visits, thirteen people agreed to be interviewed, and the spouses of three of them participated in the study as well. Given that the courses were female dominated, our material also represents this gender imbalance with eleven female and five male interviewees. The age of the elderly interviewees varied from 61 to 87. All except for two of them had lived most their lives in Oulu, and five had even been born there; the interviewees thus had long socio-spatial relationships with the city. Four of them had academic education; ten had studied in a vocational school or had an intermediate grade; and two had entered the working life straight after basic education. The public sector, mainly hospitals and schools, had employed eleven of these interviewees; three had made their careers in the industry; and two had worked as entrepreneurs.

The qualitative material has been analyzed by repetitive readings and by building categories that follow the conceptualizations of the participants. We consider experiences related to ICT and urban space as individually lived stories, told by the participants and reconstructed in our analysis [32].

5. Analysis

We analyze the material with our technology appropriation model presented in Section 3, identifying individual factors into the model.

5.1. The appropriation process of UBI-displays

The long-term usage trends presented earlier in Fig. 4 suggest that the appropriation process of public displays has largely led to either non-appropriation or disappropriation. The preliminary discussions with our young adult participants revealed that only a minority of them had actually used the public displays. Due to this we included in the cultural probe study a task where young adults were asked to try out the public displays and write down their experiences. These experiences were shared and discussed later on in the group or pair interviews. By examining this material we can find out why the result of the appropriation process has been negative.

The sheer novelty of the devices can work as a major repellent [63]. The large interactive public display does not have

a predecessor in the mediascape of the city dwellers; it breaks the boundaries between small, interactive private screens (mobile phones, tablets, computers) and large non-interactive public displays (movie theaters, digital signage) that have differing niches in the everyday life of young adults. Since the appropriation of new technology must be understood as a continuum and people always draw from their previous experiences and existing practices, a device that combines elements from very different modes of use while at the same time mixing the habitual distinction between private and public can be considered confusing and difficult to merge into everyday life. The results of the cultural probe study support this view. Due to their *unfamiliarity* the meaning of the displays was unclear for many participants and they compared them on one hand to digital billboards, and on the other hand, to smartphones. We have earlier reported a new challenge for interactive displays dubbed as "interaction blindness", i.e. people do not interact with our displays because they simply do not know that they can [22]. As one remedy we have employed proxemic interactions by displaying a simple "Touch me!" animation as a cue upon face detection but it has not noticeably increased user interaction.

In addition, participants considered the public use of a large display distressing, which was explicitly linked with the distinction between *private/public*. Information seeking was regarded to be private business; on the contrary, the usage of a display was experienced as a public performance. Some participants explained how they dislike, in a similar fashion, if somebody is standing behind them when they are using a PC. Keeping the social pattern of *anonymity in public urban places* in mind, we can interpret that the displays expose the content personally chosen by the user to a wide anonymous audience, dismantling the social anonymity of the user. Thus, even checking relatively impersonal information like bus schedules was reported as distressing by most young adults. In other words, the displays' great visual capacity turned against it; content visible also to the passers-by was thought to reveal disturbingly much about the user. A couple of participants explained how an advertisement of the *Twilight* movie had appeared automatically in the UBI-channel when they were browsing the UBI-portal and how this had been an especially unpleasant experience. The *content they could not control* seemed to impede their impression management. In addition, the fear of failure when using or approaching a display was also mentioned several times. For some of the participants this fear had actualized as the display had not responded, and they told how they do not want to test it again. The participants who managed to try out the displays felt that other people are curious and observing their actions — the well-known honey-pot effect of public displays [70]. The potential *failure is made public* and thus these experiences are connected to the aspect of impression management as well. Some concrete improvements were also suggested for the displays: the young adults wished, for example, that the displays would have some visual protection on the sides or the interactive part would be smaller, to reduce the public exposure of the interaction. Young adults also pondered how touch screen technology in the outdoors is not always suitable for northern climate.

However, the versatility of the displays' content was experienced as a positive aspect although some also commented that they can access the same content with a smartphone. The most positive accounts were given by the ones who had used a display with a friend or in group. In general, the participants who talked positively about the displays emphasized *social aspects or collaborative use*, *playfulness* and *creativity*. Also the quantitative data concerning the popularity of different applications of the displays shows that games, i.e. playful content, are favored by (especially younger) users. Interestingly, these same features appeared when discussing about the ideal use of ICT in urban space in general. Thus, they can be seen as belonging to the appropriation criteria.

The displays were not discussed a lot by the elderly interviewees since only four of them had used them so far. Some had not even noticed the displays even though they lived in the center or moved there frequently. This made a 71 year old woman ponder that the displays were not aimed for elderly city dwellers in the first place. Some interviewees had noticed the displays but had not used them, because they thought that they were meant mainly for tourists, or were advertising screens. A 69 year old man had nevertheless familiarized himself with new displays more thoroughly, but commented that 'an old city dwellers of Oulu seldom needs' the services offered in them; they did not offer him any *added value*. This highlights how elderly adults with a long-time experience of living in the city look at it: for them, it is a place where they sometimes need to go to run their errands, or where they occasionally meet their friends. However, the information and entertainment offered by the displays was aimed for people who were less familiar with that particular urban space, or for younger city dwellers. Many of the elderly interviewees were still struggling to learn how to use home computers properly; therefore, they did not want to sacrifice their time to learn to use the displays.

When asked about how the elderly interviewees would feel using the displays, they responded quite positively: they said that they would not mind if passers-by could see their interactions, though some women said that they would prefer to use the displays in a company. However, a woman who had used a display explained that 'you don't wanna stand there for a long time', thus, experiencing this practice as a performance in a public stage [41]. Overall, the publicity of the technology did not matter that much; instead, the needs of elderly city dwellers and the current applications did not quite meet. Thus, in addition to being highly unfamiliar to the aging city dwellers, the *impracticality* of the UBI-displays worked as a strong repellent for them and prevented them from appropriating the displays as part of their everyday lives. Those four interviewees who had tried to use the displays were either afraid of the public failure or the content of the display did not offer them any extra value, which reinforced the disappropriation of this particular public technology.

5.2. The appropriation process of panOULU WLAN

At the same time, most of the young adults had integrated panOULU into their daily lives; WiFi technology is easy to understand and adapt as it has several counterparts in people's lives starting from home networks. Also, the technology itself is invisible and its usage is not bound to a certain place, thus, alleviating concerns about public performance. People necessarily must rely on their own wireless devices when using panOULU which eliminates many problematic points related to public displays; their use is more private in a sense that others

do not see the content, and impression management is more flexible because they can choose freely where to browse the Internet. For most of the young adults ICT was omnipresent in the urban space in the form of personal devices, and perpetual contact [48] had become a social norm [49]. Thus, in their everyday life, the city was *a hybrid space* [50] where physical and virtual layers overlapped. It is important to note, however, that for these participants the use of ICT seemed to have quite strict social rules; for example, disturbing other people and/or talking loudly on a mobile phone in public was almost unanimously condemned, and participants were able to make long lists about places where they thought their use is forbidden or is supposed to be invisible; these lists were also quite consistent. All in all, young adults emphasized *subtle* modes of communication in public or in the presence of others. panOULU supports both the understanding of the city as a hybrid space and more discreet forms of communication in a public urban environment.

While talking about the public usage of mobile phones elderly interviewees expressed even stricter boundaries between private and public behavior: many refused to use phones in public because they had been forced to listen to other people's private phone calls for example on a train, and said that they did not want to act similarly. They emphasized the importance of privacy which loud public talking could violate [51]. They were quite aware of the public nature of the performance of using ICT on the street or in a grocery store, at least when reminiscing and narrating about this experience. The hybrid space in the ubiquitous city of Oulu did not seem to be very hybrid for our aging interviewees. They were used to a strict distinction between private and public spheres which new ubicomp technologies aim to break. Therefore, they may find new hybrid spaces confusing and not following the norms of public space that they are used to.

The elderly interviewees expressed strong emotions about panOULU. Since many of them lived in the city center they were enthusiastic about the idea of using this free open access to the Internet with their home computers. Many knew exactly where the panOULU access points were located; some could even see the nearest one from their window, showing it to the interviewer as well. The problem was that, for reasons they were unaware of, their computer could not connect to this network, or the connection worked poorly. When panOULU was launched in 2005 to celebrate the 400th jubilee of the City, the local newspaper informed (misleadingly) that the network would be available all over the City and thus for everyone. Many elderly interviewees not only reminisced about this "unkept" promise, but also talked of the current malfunctioning connection that frustrated them. For these elderly interviewees, the value of this network was foremost *economic*; however, the possibility of using the network in public places was insignificant for them. Their experiences remind us that the ubiquitous smart city is also a home for many [25], which means that the transfers between private and public are versatile, and the ways people use technologies at home are connected to the ways they are (not) using them in public.

5.3. Higher order factors: attitudes and values

Higher order factors of our appropriation model exist throughout the whole appropriation process and influence fundamentally on level 1 and 2 factors. We concentrate here specifically on attitudes and values: these factors cannot be changed by designers, but they can be harnessed for design purposes. If they are recognized it is possible to highlight directions where urban public technology should be developed in order to make it genuinely desirable and beneficial for people. For example, though most young adults in the cultural probe study considered the usage of the displays awkward, they still thought the displays could bring some added value to the city and would be useful at least for tourists. Some of them were aware of the high-tech image of the city and felt the displays are reinforcing it. In a similar fashion especially elderly men thought it was important to keep up with the technological development, and that this was a way to support the local industry. This attitude forms a fruitful ground for new innovations if levels 1 and 2 factors are not working against it too strongly.

On a more general level, both the younger and elderly participants of our study expressed both anxiety and enthusiasm when considering the future of ICT. The continuous and unstoppable development of technologies was seen as a natural state of affairs but at the same time some of the participants were strikingly distressed by the fast development and even opposed it — regardless of their age. The spectrum of opinions and attitudes was vast; thus, breaking down the perceptions that city dwellers belonging to different age groups would form homogenous groups. Likewise the attitudes, also the knowledge related to everyday use of ICT varied substantially among both age groups. The most obvious factor explaining this strikingly deep "digital divide" was the educational/occupational background of the participants of the study. Overall, the ones who were or had been studying or working in the fields of communication or high technology had more positive attitudes towards new technology, were more technologically-savvy and well aware of the new innovations. These kinds of findings call for profound user studies; the technological skills of city dwellers belonging to any age group cannot be taken for granted.

However, on a practical level there were differences between the age groups: for example, a smartphone was relatively common among the studied young adults but none of the elderly interviewees had one. The elderly were concerned with what the fast development of technologies would mean especially to the oldest members of the society. If computer literacy [52] is a requirement for competent citizenship, people without this skill are undoubtedly marginalized. The aging adults expressed worries for loosing track of the intensifying digitalization of the society. Here we see clearly how the individual lives of citizens are part of the surrounding sociocultural reality that frames the choices made [53]: though the elderly interviewees were using computers in multiple ways, they belittled their computer skills. According to Richardson et al. [54], this is connected to the way elderly people are seen in the society: if they are regarded as an economic burden with low computational skills, aging citizens themselves reproduce this image in their stories of their encounters with ICT. This probably does not increase their willingness to try out new public technologies.

Values can be traced by looking at the wishes and dreams of the participants of our study. The elderly adults' main concern on their own future was their ability to live in their own home as long as possible, but this also called for staying *mobile* and looking after their physical and mental well-

being. That is something that the design of public technology should consider. The elderly adults found it crucial that somebody *introduces new technologies to them* and that these tutors respect elderly learners. The more specific hopes for the displays were temporal layers: a man who had lived most his life in the city center suggested that each display should offer a view to that same place as it was decades ago. Overall, it was hard for them to imagine what kind of services the displays could offer them.

Some of the more specific wishes voiced by young adult city dwellers about future ICT included visions where the *functionality of technology* was emphasized; the use of a "dream technology" was described as smooth, easy and fast. Secondly, *democracy of technology* was often mentioned: participants for example wished that even small and remote villages in the countryside would have a good internet connection. Third, *ecological* and *ethical* values such as reusability and fair trade were a recurrent theme. Finally, the "naturalness" of technology was stressed. These wishes were often accompanied by comments explaining how technology should settle in the background of everyday life and not be the center of everything. They commented that it could be more or less everywhere but it should also become more invisible, more mundane and support social interaction, not steal time from it. It should not create a hasty feeling but rather be calm(ing) and less stressing. Interestingly, this last group of wishes is compatible with Weiser's original vision of ubicomp [3].

6. Discussion and results

We have interpreted the differing usage trends of two public urban technologies from the perspective of the appropriation process. While the use of panOULU WLAN has grown, the use of the UBI-displays has slowly declined. These differences indicate how technologies are never born in a vacuum, but the appropriation process is, firstly, a part of a continuum formed by individual experiences, needs, values and beliefs [33,35]. As many studies, e.g. anthropological [36,53] have shown, citizens make choices to adopt or neglect technologies based on their own needs and previous experience with similar technologies. While panOULU provides apparent intrinsic value to people, the utility of the displays is questionable, at least in their current form. While the use of panOULU can be relatively private and subtle with wireless personal devices, and WiFi is a familiar technology for many people, the usage of the displays requires public engagement with them and is unfamiliar. In addition, the interviewed city dwellers did not find the services of the displays relevant; the elderly told us they do not need the information offered by the displays, and the young adults thought they can get the same content by using for example a smartphone.

There are many technological artifacts that require an embodied interaction which people find comfortable to use in public such as vending machines, but from a sociocultural point of view, public interactive displays differ substantially from these. As our analysis showed, people perceive them as belonging to the same family as either smartphones or billboards; thus, their use and meaning was interpreted through the meanings given to these more familiar technologies. While many studies have found that people actively ignore public displays (see e.g. [55]), they are typically short-term studies conducted with public displays that are not interactive or that do not provide real services or content like our displays providing two dozen different services. Ultimately, we can ask if interactive public displays are doomed to failure or not. The premises for the design of ubicomp technologies and the more explicit design changes that may facilitate the acceptance and adoption of urban public displays and other similar technologies are discussed in the next sections.

6.1. Reflection upon recent ubicomp research forecasts

In a broader context, we reflect on our study on three recent ubicomp forecasts. Rogers [56] called for a change of direction in ubicomp research, outlining an alternative agenda focusing on engaging people with technology instead of calming them with invisible computing technology proactively doing things on people's behalf. She argues how ubicomp should turn, for example, to a more playful direction. Also in our research material collected from young adults, creative and playful possibilities of technology surfaced (for example communal writing, listening to music in public, dancing); these aspects resonate interestingly with the future visions of ubicomp presented by Rogers.

Bell and Dourish [58] argued that instead of pursuing an unattainable futuristic ubicomp technology vision rooted in seamless interoperability and homogeneity, we should acknowledge that the future (ubicomp) is already here in the form of messy and heterogeneous technologies assembled to produce individual and collective effects. Given that, we should focus on obtaining a deeper understanding of the social and cultural practices emerging around novel information technologies. They also noted that the future that is already here is not necessarily very evenly distributed. First, it can show in the power relations embedded in access to infrastructure; second, as different technology adoption and use patterns in different cultural settings; and third, as a concern of encountering and navigating inherently messy and uneven infrastructures. Our analysis confirms that the "future is not evenly distributed" among the current or potential users of our urban public technologies due to complex social, cultural and societal circumstances. The studied young adults and elderly adults did not form uniform groups. For some of them, the futuristic visions posed by ubicomp were reality, brought about by newest mobile devices and applications that turn the city into a hybrid space; some were not so technologically-savvy and found the technological reality and its promises scary, repulsive and unreasonable. Public urban technology design should acknowledge these varying attitudes, skills and needs, as well as practices built upon them, if we wish to avoid strengthening the unequal structures.

Williams et al. [25] presented two starting points that should be taken into account in the design of urban technologies. First, they argue that built structures are not just a fixed setting where ICT can be planted; rather, they are changeable environments whose meanings are dependent for example on the people moving through these spaces, context, time of the day and time of the year. These rhythms should be investigated and taken into account when designing urban technologies. Secondly, they argue that home and the city are not separate domains. These aspects were visible in our material in a sense that different age groups had differing conceptualizations of the City of Oulu and technology's role there; the multiple time layers and diverse

histories of the city dwellers intersect with the discourse of the high-tech city and also with other larger sociomaterial structures. Thirdly, young adults claimed for example that "the walls of the home are invisible" because of the ICT; thus, the distinction between the home and outer world cannot anymore be understood by drawing a strict line between private home and public city. These distinctions have become complicated and call for a more nuanced analysis.

6.2. Design challenges for urban public displays and technologies

Returning to the main questions posed in the very beginning of this article, we can conclude that at the moment our "smart city" is not smart for everybody, nor do the services offered meet the varying practices of all city dwellers. Additionally, the dynamics of the public space pose specific problems that need to be taken into account. The idea of a public interactive display is highly intriguing; still, in order to make them sensible and useful to all the city dwellers, several points must be highlighted. Keeping the presented ubicomp forecasts and the results of our own study in mind, we discuss in detail these identified design challenges related to urban public displays and technologies. We present both solutions *we have used* and also *potential* solutions to the appropriation problems showed in our model.

6.2.1. Level 1 factors

6.2.1.1. Familiarity. Unfamiliarity of the technology is a great challenge when considering the urban public displays. This has been addressed in Oulu by employing "UBI guides" during several summers; they have been moving around the city center and have introduced the use of the displays to city dwellers and tourists. Similarly, "panOULU clinics" have been arranged around Oulu to familiarize the general public with the WiFi network. However, the impact of these activities is difficult to measure. Confusing our displays with non-interactive billboards was recognized as a part of the problems posed by unfamiliarity; perhaps less business-like esthetics could separate them from non-interactive billboards or digital signages and also make them more appealing (e.g. [60]).

6.2.1.2. Preserving anonymity and respecting boundaries between private and public. Being distressed by the public exposure of interacting with the displays was a recurrent theme in our qualitative material. Thus, problems related to this aspect should be further investigated. A different kind of placement of the displays could help diminish the distress related to public use. Currently, the outdoor displays are situated in the middle of the streets; should they be placed near walls of the buildings or be even integrated into already existing structures? The great visual capacity of the displays was depicted as a problem in interactive use when seeking information. One way to overcome this would be to design applications that take advantage of that capacity. Our culture already puts enormous weight on visual aspects so combining interactivity and visual capacity in a comfortable and attractive way must be possible (e.g. [61,62]).

6.2.1.3. Control, reliability, practicality. People using the technologies in public need to feel they are in control of what they are doing. The content (advertisements) that users cannot control during interactive sessions with the displays was experienced as distressing; maybe it should be shown in a more subtle way. The reliability of new, especially public technology is highly important; otherwise many will try it out only once. Practicality can only be increased by careful grassroots level user studies; how technology would better fit into people's everyday lives and practices.

6.2.2. Level 2 factors

6.2.2.1. Social management, information management. In Oulu's case city dwellers' information needs were studied before the implementation of the displays and findings were used when designing services. However, the real-world deployment revealed interesting differences between the public's self-proclaimed information needs and their actual information behavior [21]. Also this calls for more nuanced user studies; we cannot simply ask people what they want but we need to study their behavior and everyday practices. It is crucial to find out how people use existing technologies in public as they will adopt new ones only if they resonate with their needs and fit into their lives [63]; already appropriated technologies have proved to be worthwhile.

6.2.2.2. Creativity and playfulness. Although information seeking is one important use of public displays, our study indicates that creativity and playfulness should also be studied more profoundly. These aspects have been explored with various services of the displays, including different games, art, and UBI postcards [73]. However, when thinking about the future of interactive public displays, we should broaden our understanding of creativity and playfulness. We can draw for example from the research of urban lighting which is also an immobile public technology strongly connected to visual sensation; perhaps public screens could enhance the city space in similar ways than a carefully designed lighting: by offering people esthetic experiences, by affecting the atmosphere and by increasing the feeling of security.

6.2.2.3. Collaborative use. A past literature on audience participatory systems shows that the physical and social setting is essential to their success [74]. Public displays are known to foster the physical and social setting via co-location [75], i.e. by bringing people together at a display to use a service that stimulates inter-personal communication within a group of people as they jointly pursue a common goal, which in turn strengthens their strong social experience as a group. This has been demonstrated with the new Wordster game deployed in the displays in spring 2013 that soon became the most popular service [76].

6.2.2.4. Supporting prevailing social norms. If we wish to design technologies that fit into existing social norms, the norms need to be studied beforehand. They are always dependent on the context of the use. It is important to pay attention to cultural differences that shape norms: For example, in Finnish culture *shame* is understood in a specific way, and the behavior of people is controlled, to some extent, by casting shame on the individuals that fail publicly. In other words failing in the sight of others needs to be avoided because it gives an individual a

social stigma (e.g. [59]). This kind of cultural trait can of course, have an influence on peoples' willingness to engage with novel public technologies. It would be extremely valuable to compare the norms of public space and ICT usage found in Oulu with another city. However, we argue that the effect of public place on technology is reciprocal; technology can also have an effect on public space, and change its socio-spatial structures [57]. The social norms are constantly negotiated as new devices, applications or services enter the public places.

6.2.2.5. Supporting situated actions. Our real-world deployment has revealed that displays located in different places are used in differing ways. This implicates how meaningful the location of the display actually is. Location-based, exclusive services would make them more attractive, and if the information or experiences they offer would also be tied to the location and their surroundings, the immobility of the displays would become intelligible and useful. From a broader point of view, cities are highly diverse, and for instance, the northern location of Oulu poses its specific problems for urban computing — but at the same time it can also offer possibilities. Technology could offer specific solutions or experiences for people living amidst snow and the darkness of the winter. Thus, the special features of a particular urban environment should be taken into consideration. As Williams et al. [25] argued, "the city" does not exist; we only have diverse cities.

6.2.3. Higher order factors

Higher order factors refer here mainly to peoples' attitudes and values, always bound to a certain place and time, and formed through historical, cultural and social processes. Researchers or designers cannot change these factors, but they should be taken into consideration when designing large-scale systems potentially affecting many people; they can also be used when forecasting the future, and therefore we are claiming in our technology appropriation model that values can be understood as *potential reinforcers*. For example, for elderly people participating in our study staying mobile was one of the main concerns. The technologies that attempt to bring activities into certain locations outside the home could, in theory, support this kind of mobility. As the population age structure in Finland is changing due to low death and birth rates [65], technologies supporting elderly peoples' wellbeing should be taken into consideration also by urban comp. On the other hand, young adults emphasized many features that public urban technology actually already entails, such as democracy of technology. Thus, higher order factors do not necessarily hamper the appropriation of public displays but the problems are on levels 1 and 2. In addition, values connected to sustainability and ethicalness as well as the "naturalness" and calmness of technology use and interaction were stressed by younger participants. These aspects should be further analyzed, and technologies, applications and interaction models around them developed.

7. Conclusions

This paper explored the appropriation of two public urban technologies, municipal WiFi and interactive public displays, through a three level technology appropriation model. The municipal WiFi has been adopted very well and its usage is increasing rapidly. The adoption of the interactive public displays has been slow due to several factors, such as the unfamiliarity of the technology and its questionable utility; in addition, people are concerned about engaging with public displays in public settings. Of course, appropriation can be a long process and these two technologies represent different phases of it; the WiFi has been available for a much longer time than the displays.

Our study indicates that the appropriation of a new technology in urban surroundings is a complex process that cannot be fully understood without long-term and in-depth multidisciplinary studies. However, by examining both quantitative and qualitative material it is possible to unwind the process and identify the factors either supporting or hampering the adoption of new technologies. It should be noted that different demographic groups may experience these factors in differing ways; for example, for young people the creativity and playfulness of the applications was a more attractive feature than for elderly, who in turn emphasized the utility. By using a micro-scale approach we can also investigate deeper sociocultural factors affecting the appropriation process and take them into account in the design. The importance of these "background" factors means that the research of urban public technologies must always be contextualized.

Urban technologies are often designed to fit into a certain kind of social practices, with a certain kind of an imagined user in mind. Conducting in-depth qualitative studies on the age group of young adults and elderly adults revealed that skills, needs and attitudes are not uniform, not even inside a demographically rather homogenous group. The bias in the design and problems in appropriation process could be diminished if different kinds of people using the public urban space were involved in the design process by using for example participatory design [16]. The messiness and diversity of urban reality go far beyond the imagination of a designer.

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