Democratizing Ubiquitous Computing
– a Right for Locality

Sebastian Weise, John Hardy, Pragya Agarwal,
Paul Coulton, Adrian Friday, Mike Chiasson
Lancaster University
{s.weise, j.hardy, pragya.agarwal, p.coulton, a.friday, m.chiasson}@lancaster.ac.uk

ABSTRACT
Trends such as the increasing adoption of smartphones, the development of the service-oriented internet, and diffusion of sensing technologies into cities have the potential to combine in order to form a ubiquitous computing infrastructure. At the same time, as the computer diffuses into the physical world, it loses its location-neutrality, exposing the urgent need for a debate of design choices in ubiquitous computing. In this paper, we discuss the process of urban development as a source of inspiration for such design choices. Looking from the ground up, of particular interest is the opportunity to localize and democratize an emerging ubiquitous computing infrastructure. The design choices we negotiate today will determine the society in which we will live in the future.

Author Keywords
ubiquitous computing, urban process, democratization, data rights

ACM Classification Keywords
H4.0. Information systems application: General.

General Terms
theory, design, human factors.

INTRODUCTION
In a world in which many physical objects gain the ability to generate data about their environment, we are faced with questions about how to ensure that the value of this data is shared for the common good rather than kept for the corporate interest of a few global companies. While a great strength of information communication technologies (ICT) has been to break down the barriers of geography, as digital devices diffuse into the physical world, such as with ubiquitous computing (ubicomp), their relationship with the physical locations in people’s lives strengthens. In advanced cities, the emergence of a ‘ubiquitous computing infrastructure’ as a general purpose utility moves closer through new paradigms such as “urban computing” [60]. Recently, scholars envisaged further combining previously disconnected data sources [59]. This alludes to a shift in society’s behavior on a large scale, wherein the ownership and management of ‘ubiquitous data’ as well as the underlying infrastructure is far from clear [12]. This raises fundamental questions about who designs, controls and uses the data generated from individuals’ activities.

Cities are places which feature a high density in technological infrastructure and social activity and thus function as today’s testing grounds for novel ubiquitous computing technologies (e.g. [48]). In this article we seek to explore democratic issues and choices in the design, control and use of ubicomp systems through a discussion of the process of urban development, which we consider to be a societal process focused on effecting urban change.

This paper is structured in four main parts. After a brief introduction into the issues involved in scaling ubicomp technology to a societal level, we describe core essentials of the urban development process. We then explore the current state of selected existing ubicomp systems relevant to today’s urban environments with a focus on delivering a next-generation infrastructure and propose a framework informed by the urban process. Finally, we discuss a possible future in which ubiquitous computing enhances the social process of urban development.

The role of ubicomp as infrastructure in these activities is becoming increasingly important and has the potential to exhibit many potential negative and positive effects. The extent to which these effects are manageable, and indeed felt, will depend greatly on the design choices which control the use of the data that people generate. We believe it is important and timely to open a discussion around this topic to help develop a society which is able to design, control and use ubicomp infrastructure and the data it generates to help meet society’s needs. In doing so, we hope to avoid fear of a dystopian surveillance society and instead work towards a world in which ubicomp data serves the collective good.
Evolving visions of ubicomp

A key part of Weiser’s original vision [55] was the concept of an interoperable, ubiquitous ICT infrastructure with many unobtrusive interfaces to the physical world materialized through simple devices embedded in the world, supporting natural interaction with their users. As we now know, his vision catalyzed a broad research field, which encompassed investigations into new forms of sensing, smart artifacts, context-awareness, and many other areas [46]. Ferscha [23] summarizes the emphasis throughout the years as being on ‘connectedness’ (late 1990s – 2000), ‘awareness’ (early to mid 2000s), and ‘smartness’ (mid-2000s to present).

Increasingly, the direction of the research community has been critiqued. For example, Bell et al. [3] noted a tendency to focus on a never-quite-achieved immediate future, which translated into a lack of regard for already adopted ubiquitous computing technologies. For Rogers [46], ubicomp research has lacked an understanding of people as ‘proactive actors’, who should be supported in the social activities they already do, rather than continued demonstrators and proof-of-concepts with a ‘technology-led’ focus divorced from real-world problems [49].

As a result, while many prototype systems exist, twenty years after Weiser’s original vision, challenges remain not only in the scaling and use of ubicomp technology and its integration beyond the home or office [1], but also in its social acceptance and general availability in the public realm [12]. Below are three such aspects to these unresolved issues:

- Concerns about the ethics of the social impact, particularly relating to user data privacy and security [12,18,17,46] through the ability to collect behavioral, personal and biological data [58].
- Lack of examples of feasible business models for the large-scale application of ubicomp technology [9]. This is further exacerbated by the lack of long-term studies of existing use cases [49] and the absence of large-scale well-defined scenarios.
- Lack of standards [12] as well as continuing technological challenges in context and activity recognition [33].

Addressing these challenges, Abowd et al. [1] highlight how individual ubicomp systems need to ‘create compelling stories’, which can provide implementation goals, perceived benefits, and success criteria for the technology. Additionally, McCullough [37] specifically calls for a “focus on habits rather than novelties, on people rather than machines, and on the richness of existing places rather than inventions from thin air”.

We agree in principle with both statements recognizing that the diffusion of ubiquitous technologies into society is an inherently complex and uncontrollable process. Indeed, this is especially true once we move beyond individual ubicomp applications (e.g. an ICT-supported car rental scheme) towards what we might call a ubicomp infrastructure, meaning the collective of connected ubicomp systems (e.g. a car could be rented through a mobile device and its mobility could be tracked for traffic monitoring).

Such an infrastructure stretches the capabilities and possibilities for data collection and use, and moves ubicomp towards the center stage of society as mentioned by Zhang et al [59] through a combination of developments: These include changes to the internet to be more content-centric and ‘social’, the widespread adoption of powerful portable devices in particular smartphones, and the diffusion of stationary infrastructure sensor technologies into the urban environment. Due to this increasing emergence of data flows, it is even more important to consider the design choices that promote or inhibit democratic participation in the design, control, and use of ubicomp systems and data.

We now discuss the urban process with its main issues (including scaling, local change and negotiation between different stakeholders) to explore design choices for a ubicomp infrastructure and the data generated from it. Here we use urban process to mean the process of urban change without explicitly assuming agency of particular people in the process. Later we specifically reflect on the urban development process, which includes planning within an urban context, including both a participatory, user-led approach, as well as the institutional process of planning within a prescribed set of guidelines.

THE URBAN PROCESS

In this paper, we view the making of the city as a complex process made up of flows of financial capital, physical resources, people, and now increasingly also information and ideas [11,15,57]. The flows are entangled in the power dynamics of people controlling and augmenting them, which in turn affect the construction of the city. This leads Massey [35] to describe places as “articulated moments in networks of social relations” without clear boundaries, continuously influenced by networks which reach beyond a particular place.

Scales implicit to the urban process

The urban process is a scaling problem in which mutually dependent parallel processes play out across multiple different spatial and temporal scales. Wegener et al. [54] differentiate between long-term change processes related to the physical built environment with lasting effects of up to 100 years, medium-term changes related to socio-economic activities undertaken in the city which may manifest within 20 years, and short-term changes such as the daily mobility patterns which may change very dynamically from day to day.

An observer may often find it very difficult to perceive the slow changes to the city. For instance, the built infrastructure is far more durable because of social rules in the form of land ownership and thus Wegener et al. indicate that it changes only 2% each year compared to information in digital form, which may have a much shorter use value.
Independent, relatively minor, adaptations to the urban environment can be considered ‘indirect design’ [13]. An example of these independent adaptations is the number of planning applications, which represent individual investment decisions in the context of a legal framework. This compares to larger-scale infrastructure investments such as the development of a new railway line, which demand the mobilization of considerably larger number of factors and involvement of more actors and thus takes place on a much longer temporal and larger spatial scale.

Urbanization is strongly linked to proximity and the sharing of resources, which helped people live more efficiently together for trading and protection. While ICT has weakened the first law of geography (objects in close proximity are likely to show more similarities [38]), studies continue to show the importance of proximity in the social life of individuals [27,45]. While change in the city can be broken down into various level of spatial abstraction starting with a specific location, pinpointed through a relatively precise geo-code to citywide scales defined by institutional boundaries, citizens socially construct an understanding of places and neighborhoods in their city as well as its spatial scales [22]. Additionally, communities inhabiting the city may develop multiple understandings of particular places and territories. Williams et al. [57] mention that most ICT systems in this context tend to over-emphasize design for the affluent and mobile ‘flaneur’ while disregarding other minorities such as immigrants and the homeless, which also contribute to the feeling of a place.

Infrastructures and the urban process

For a large part, urban development has been concerned with a replication of infrastructures, defined by the Oxford English Dictionary as “the basic physical and organizational structures and facilities needed for the operation of a society…”, which enable the flows mentioned previously (i.e., finance, goods, people, information) across different spatial and temporal scales. From the discussion of infrastructures, we highlight two main points.

The enabling power of infrastructures

Infrastructures are prerequisite for cities to function, they provide the ‘habitat’, which helps or hinders particular social activities. In recent years, the availability of large-scale data capture and analysis has contributed to our understanding of how urban populations and their infrastructures relate.

In a landmark quantitative study, Bettencourt et al. [5] used a wide range of statistical data (such as electricity consumption, length of road networks, employment figures, and number of registered patents) for a sample of US, Chinese, and European cities. They arrived at a universal scaling ‘law’ in which economies of scale in physical infrastructure are in tension with economies of scale in social properties: As a city doubles its population, infrastructures would scale sub-linearly, indicating higher usage efficiency. At the same time, those from social interactions (such as crime and innovation capability) scale super-linearly by a factor of approximately 15%. These results imply that, theoretically, there is no limit to a city’s growth as long as innovative capability through social interaction produces increases in efficiency in the underlying city infrastructure at an increasing speed.

A potential benefit of ICT in this case is that it can become a major driver for increased efficiency for cities. Cuff et al. have mentioned the potential of ubiquitous computing application in urban development [20] and it was noted that mobile phones, for instance, have the potential to enhance interactions within a city through immediate feedback loops. These and other similar technologies enable the augmentation of ongoing processes and decision-making based on near to real-time information [52].

The social construction of infrastructures

The manner in which these infrastructures are designed, managed and used is reflected in the organization of society. This is due to the social powers within which these infrastructures are embedded [35]. Electrification, for example, as the last infrastructural paradigm shift [42], saw the shift from local production of electric energy by consumers (i.e., steam and water turbines) to centralized, but more efficient energy generators managed by large utility companies, which subsequently gained more bargaining power. Carr et al. [14] argue that a similar process is emerging for computing resources, citing the example of the adoption of cloud services on the internet: In electricity networks the application of the electric energy would still be enacted locally through an ‘electronic endpoint’, i.e., a physical device. Digital infrastructures however take the additional step of remotely running the application, which means that service providers can manage the application of computing resources and the output in terms of data at the same time.

A ubiquitous computing infrastructure can play an important role in enabling and enhancing beneficial social processes as, unlike electricity, digital infrastructure enhances a society’s cognitive power by its ability to connect people and information [39]. While infrastructure projects in the past had the idealistic notion to connect the urban realm and its communities of different ethnicity, wealth, and beliefs, Graham et al. [28] note the increasing fragmentation of the management and ownership of infrastructures. They make the point that an “infrastructural individualism threatens to emerge” in which disadvantaged groups could be further marginalized. In this way, a ubicomp infrastructure could also have the potential drawback of excluding those who are not in direct control.

Urban development as social process supported by ubicomp infrastructure

In the discussion of democratization of ubicomp infrastructure with the intent to achieve an open society, we attempt to uncover the fragmented ICT landscape in cities through a contextualization of their power dynamics. To further the discussion, we propose a conceptualization of the urban development and the key stakeholder groups involved (Figure 1). This provides a way to reflect on the
design choice possibilities for community management in an emerging ubicomp infrastructure. This framework contains implicit notions of spatiality, whereby local individuals, their representative public authorities and 3rd parties (i.e. businesses and other special interest groups) are, through a simplified view, considered in the context of their use of ubicomp data. While public authority is localized to support a particular community, businesses may provide services on a global scale.

Figure 1: A value network for ubicomp data

Each of these stakeholder groups maintains some private repository of data generated through different means, for example:

- **Individuals** (1 in Figure 1) ‘own’ demographic data, produce user-generated content through online interactions, and additional contextual data (such as mobility or payment data) through interactions with ubicomp devices.

- **Private businesses** (2 in Figure 1) aggregate information such as customer statistics and other non-public operation-relevant data. They also generate some public content in the form of adverts or general information.

- **Public authorities** (3 in Figure 1) maintain large repositories of statistical data collected from the citizens or businesses and others beyond [36]. Data includes planning applications, tax payments, and social care statistics.

- **Community data repositories** (4 in Figure 1) are emerging aggregators for local ubicomp data coming from the above three stakeholders.

Conceptually, the urban development process involves data and information collection as well as exchange between the different major stakeholders for the purpose of achieving social value. Use case examples for data exchanges may be official voting (A), social media services (B), and taxation (C). While data is shared amongst each group with various levels of privacy, some is specifically used in public discourse such as the urban process. We considered such data as ‘community data’ (4 in Figure 1), used here to imply the data that is generated in an ubiquitous computing infrastructure through interaction with ubiquitous devices with relevance to the area in proximity to these devices. Existing use case examples of community-relevant data collection include open data stores or civic dashboards established by cities such Birmingham [6] (D), participatory sensing initiatives (E), and traffic monitoring through mobile phone networks (F).

We argue that it is this process which ubicomp aims to support at a societal level. The various choices for the democratic influence of people on the collection and use of data, and the design choices for the ubicomp infrastructure are in front of us now. The choices made today will have a dramatic effect if and how this infrastructure will serve (or not serve) the citizens.

In the next section, we explore the current form of this emerging ubicomp infrastructure. Appreciating the criticism by Bell et al. [3] we review examples of ubiquitous computing systems operating in urban environments today with respect to their potential to generate community data.

**FRAGMENTS OF A UBICOMP INFRASTRUCTURE**

In exploring how the bundle of ubiquitous computing systems may develop into an infrastructure, it is essential to understand not only the types of digital technology in urban environments today, but also the design, control, and usage scenarios that are typically used in their implementation. In doing so, we will need to go beyond the traditional focus of ubicomp technologies and also include projects related to mobile computing as well as the open-data movement, which originated from the opening up of public data repositories by public authorities.

Figure 2: Mapping of current ubiquitous technology

Temporal and spatial scales are important not only to the urban development process, but as Carceres et al. [12] note, also represent challenges for data management in a ubiquitous computing infrastructure. We aim to consider the scale
of application of the particular technology as well as the use of the technology by mapping a number of existing digital networks listed in this section onto the geographical scale in which they are located and the accessibility of the data in the particular system (see Figure 2). This overview is by no means exhaustive but should help to understand the diffusion of digital technology into the urban process today. We see the following developments:

**Top-down sensing applications**

In cities, a number of large-scale urban monitoring projects rely on mobile phone networks. Researchers at MIT’s Senseable Cities lab for example were among the first to use mobile phone data to understand urban mobility. Example projects include ‘Graz in Real-Time’ [45], Real-time Rome [10], and Live Singapore [48]. Initial projects provided proof-of-concept systems with a focus on the arts. Projects are largely based on anonymized real-time data from large communication infrastructure providers (case F in Figure 1), where mobile phone users provide no formal opt-in. Potential emerging applications include traffic and bus route planning, but also individualized applications such as detection of mobility preferences and capturing of personal environmental impact [4] (case B in Figure 1).

Other examples that facilitate city-wide mobility infrastructures include the sensing of urban traffic in which taxis are used as mobile sensors to inform failures in urban planning [60], or the identification of urban dynamics through data collected from a bike sharing scheme [25]. Additionally, these providers are often city-specific. In comparison to mobile phone network data, the advantage here is that shared infrastructure is used in order to understand city dynamics without the need for monitoring individual traces.

**Participatory sensing**

Another stream of work includes participatory sensing applications [8], in which citizens deliberately and knowingly upload data they sense through devices, such as mobile phones (case E in Figure 1). This emergence of mapping techniques, or participatory GIS, for local communities, can empower grassroots organizations and disadvantaged groups by providing shared narratives and a sense of awareness through the data to support their cause [50]. Increasingly, geo-referenced content is submitted directly from mobile phone platforms, which use the camera and microphone of the device. Researchers point out that soon phones could also include sensors for capturing other characteristics of the environment, such as temperature and humidity [20]. Systems are often limited to a single purpose [40], such as noise sensing [30,34]. Another recent area of success is represented in the OpenStreetMap project, a large crowd-sourced and open-source mapping data repository based on input from 33,000 ‘social sensors’, which generated a free-to-use, open-source competitor to dominant commercial mapping providers [29].

**Infrastructure sensing**

Other companies focus on the development of platforms for the sharing of data from stationary physical sensors from other ubiquitous systems such as sensors in buildings. Infrastructure providers have conducted much research into sensing the street traffic and electronic consumption. Companies such as Pachube/Cosm [19], which connect sensing devices, aim to provide platforms for an ‘Internet of Things’ (case B in Figure 1).

The urban environment today includes many situated devices already used as sensors, such as CCTV systems, but the examples mentioned above previously (e.g. a collection of bike racks used to sense urban mobility), suggest that there are many other opportunities for information sources and devices one could use. Traditionally, these have not received much attention from the research community, such as parking meters, ticket machines and ATMs.

**Public displays**

Public display systems point towards future interface technologies in a ubiquitous computing infrastructure. Typically these are situated in the public domain and have been used to provide public access to community data. Nevertheless, interactive public display systems that take advantage of such data streams remain rare. Recent examples include the UBI hotspot system in Oulu, which distributed interactive screens throughout a town center [43]. These afford individualized interaction directly through touch, or indirectly through mobile phones to share photos, videos, or short text messages. Here they have faced some of the intricate data management challenges that arise when individual user input, local community information, and 3rd party commercial information interact and become visible. In a similar manner to the UBI-hotspot system, a campus-based display network is used at Lancaster University to disseminate community-relevant information [51].

**Open and hyper-local data**

A related important development driven in particular by governments today is the recognition of publicly available data sources. In several cities, open data initiatives have resulted in the establishment of hyper-local data stores, i.e. locally-collected data available globally (case D in Figure 1). New types of content management systems are emerging, which are specifically tailored for the distribution and management of data feeds, such as the open-source project CKAN [16], which powers the datastore of the Greater London authority. Apart from the local storage and management of the data, new ways of engaging with local data are needed to provide connections between local data capture and actions that results from it. The representation of community data is largely nascent and we know only of examples where the representation is largely aimed at informing and less at encouraging action. Example projects include the recent implementation of dashboards to visualize statistics of citizen requests made to a city council [6] and the visualization of local communication in a business cluster based on Twitter data [53]. In the context of urban planning, as introduced in Figure 1, these initiatives could present community data repositories on different spatial
scales, in which data flows combine together to support local decision-making.

At the same time, we can identify a trend of large web companies to capture much more personal data on their users than ever before. More data of citizens relevant to the public discourse is shifting into the realm of social media. Here large global companies set out how collected data is used, managed, and stored, although data use may be for public purposes and local interest. Cases include search companies, which recently embarked on a restructuring of data management policies to profile users for better advertising by fusing data items such as mobility, website browsing behavior, and social network information [31] (case B in Figure 1).

Discussion
In the context of urban development, the knowledge and creativity of citizens is leveraged to contribute to the development in their local area [7], and as such it is important to appreciate the contributions individuals make through their interactions to their local environment. Studies show that individuals are largely habitual in their mobility and likely to return to only a few locations frequently [27]. Evidence suggests that they are more likely to participate in decision-making on issues in their own proximity [2]. That indicates that as digital devices diffuse into neighborhoods, there is a case for public ownership and control of data relevant to an urban community. Further, this strongly suggests that location is central to the management structures within any future ubicomp infrastructure.

A key question will be how the various examples of ubicomp systems cover and avoid particular approaches to citizen-led influence over a ubicomp infrastructure. The urban development process is a public process of participation [7] between various stakeholders, some of which have formal roles (e.g. urban planners, business owner). In a future ubicomp infrastructure based on the notion of ‘community data’ citizens may perform informal functions by interaction and management with the infrastructure and its data.

Given that individuals today are major creators of digital content on the internet, ubiquitous computing should enable their active contribution to urban development through decision making acting on data generated locally. Such contributions are increasingly made through crowdsourcing applications as a general-purpose problem solving technique enabled through ICT, in which a large group of citizens would explicitly collaborate to build “a long-lasting artifact that is beneficial to the whole community” [21]. Examples such as Wikipedia have shown that motivations to participate in crowdsourcing models are manifold and do not necessarily require financial incentives. Here new social functions may need to be negotiated for working with community data. We outline this with a schematic flow of how stakeholders augment their local environment (Figure 3) with a focus on data collected and how it supports the urban development process as described previously. Inspired by research on social roles in online crowdsourcing systems [26], as a starting point, we propose that the following roles may emerge in ‘community data’ management. The list is not exhaustive and any one stakeholder may, at different stages, perform different functions in the process. Subsequent work is needed to enumerate and understand them all.

![Figure 3: Schematic view of potential stakeholder roles in ubicomp data management](image)

<table>
<thead>
<tr>
<th>Function</th>
<th>Potential actors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content producers (inc. situated devices)</td>
<td>Individuals through personal and interaction data; automated sensors monitoring environmental data (such as traffic)</td>
</tr>
<tr>
<td>Aggregators</td>
<td>Community organizations such as business improvement districts and neighborhood watch programs</td>
</tr>
<tr>
<td>Connector / Curators</td>
<td>Actors who merge and curate data from different aggregators to derive a trusted ‘community data set’ from business, individual, and government data</td>
</tr>
<tr>
<td>Mediators</td>
<td>‘Information brokers’ who disambiguate different sources of information</td>
</tr>
<tr>
<td>Facilitators</td>
<td>Individual activists using data to drive change</td>
</tr>
<tr>
<td>Implementers</td>
<td>Actors affecting change in the urban environment based on plans developed by use of ubicomp data</td>
</tr>
</tbody>
</table>

Table 1: Potential user functions in ubicomp data management

In such a location-sensitive infrastructure, there exists several ambiguities with regard to data communication:

- **Localization of data and its management**: for data we need to ask where would ubiquitous computing infrastructure house gathered data, how origin, attribution, and traversal is logged and whether it would be possible (or worthwhile) to forget it [12]?
• **Remote access**: Ambiguities exist with respect to the local specificity of computing services and the accessibility of data from outside of the context. Should we be able to access a public CCTV system 2000 km away or should there be local restrictions in place that prevent such a scenario from happening?

• **Place vs. networks**: Related design choices include the level of automation, the locus of control, and duration of settings [37]. Will we face different ubiquitous networks at a particular public location or will we interface with a unified service layer, which centralizes the various options that a ubiquitous computing infrastructure affords [44]?

In the next section we will focus on the first two design choices, which address the concerns about ubicomp infrastructure’s social impact as noted in the introduction. We do so by reflecting on the lessons we can take away from studying the urban development process to develop positions on the two principles of individuals’ rights to data contribution and community data control for deriving a possible future scenario for ubiquitous computing infrastructure.

**DEMOCRATISATION AND CONTROL**

Democracy in the urban development process implies that individuals have both an equal stake as well as a right to participate in the shaping of the local environment. As digital devices diffuse into the physical world, we argue that the impact of data is often strongest when reapplied in the context of the source that generated it. Therefore we believe that a future ubicomp infrastructure needs to feature a sensibility for local control.

Furthermore, data management in a ubiquitous computing infrastructure should avoid an imbalance of data flows (such as to stakeholders 2 and 3 in Figure 1), which are of relevance to a local community. In this case we can see the need for local control of the community-relevant infrastructure. In a future ubiquitous computing infrastructure, it would be incorrect to assume that technology could be only owned by the people, but while specialized infrastructure providers could compete for and contribute to the deployment and running of the hardware and related software interfaces, the key democratic aspect comes from the transparency of data management, in which each individual maintains a right to decide individually whether and what data to contribute depending on the situation and service or perceived benefit received in exchange.

**Identification of individuals**

In a ubicomp infrastructure the ability to identify an individual is a major issue users are concerned about [61]. Research shows that despite localization service providers having privacy policies in place, data is often collected from which the individual can often be identified regardless of the anonymization applied [4], probably due to the relative regularity in people’s mobility patterns [27].

The internet for a long time offered anonymity through the ability to use pseudonyms and to provide identity components, that were not necessarily checked by service providers. While a discussion of identity management in ubiquitous computing has yet to reach a consensus, private business platforms already function as ‘passport issuers’ for internet services through their authorization portals. This development appears to imply a shift of data to private business (shifting to the right hand side of our model in Figure 1). Alternatively, in the online sphere, nascent services, such as Mydex [41], which intend to provide personal data stores, may offer interesting choices for how to connect personal ubiquitous devices to such a data store with self-set sharing guidelines for personal data to which the ubicomp infrastructure needs to adhere.

Furthermore, based on the discussion of the urban process, there are different uses of data shared by the individual (as indicated in Figure 1). The individual can share data with private business in exchange for a service, where the aggregate of usage statistics may be useful for a local community (such as in the case of taxicab traffic monitoring [60]). In another case, the individual may choose to share data with a public authority, for instance, in the case of a public vote for which authentication of the user may be necessary to provide legitimacy. Eventually the individual may decide to contribute data from ubiquitous systems to a community purpose such as in the case of participatory sensing or local neighborhood watch program.

Indeed, in the context of the public places where we are still rather used anonymity of our digital identities, it will occasionally be desirable and perhaps critical to be identifiable if contributing data to the local sphere. In the case of urban planning it may be desirable to establish whether a user in a localized ubiquitous computing infrastructure is a local resident and thus entitled to participate in voting initiatives. The VoiceYourView project [56] provides an example how ordinary visitors in a place can contribute to urban change through commenting on their environment. Participatory initiatives such as the OpenStreetMap project for example decided to make their users identifiable in order to add a level of traceability, which is used as a tool to discourage copyright infringement [29].

**Community Rights Management – Right to locality**

Appreciating the potential for complexity to emerge bottom-up through rich interaction [38], we advocate the ubicomp community to focus on infrastructural efforts supporting local communities in control of data (as mentioned in the preceding section). Given the increasing decentralization in decision-making made possible by the internet [7], which enables individuals and groups alike to organize themselves, we think that location-based control of data distribution should be given greater control in a ubicomp infrastructure.

Whilst it could be argued that the individual owns the data they generate, moving and living in the urban environment
makes them part of one or more communities. Generated data may be of value to the community inhabiting that environment. While the data is potentially also of value to parties beyond the locality in which it was collected, as the data relates to those who occupy that space, we argue that they should be given the opportunity to decide which data and the level of its granularity is made available. Community-driven management realms could be established through forming of partnerships on the local level. Examples for such partnerships could be neighborhood watch programs for residential areas or business improvement districts for town centers in which co-located participants make decisions for the local area.

To support public processes by involving citizens, we argue for the need to implement a community rights management system for ubiquitous computing data, which is underpinned by the appreciation of localization in ubicomp data management. For such scenarios, data from the public ubiquitous devices generated within a local area does not need to be hosted by location-neutral global companies, but may arguably be better managed by the local stakeholders involved. We argue that the infrastructure for community repositories enabled through associated ubiquitous computing devices (e.g. localized sensing infrastructure) needs to be managed by the local residents similar to cooperatives to provide accountability. Data collection through user involvement would retain the management and ownership in local hands.

Nascent open-data storage clouds (such as CKAN) may provide inspiration for how local ubiquitous devices could feed into a data store for community-data. Gerhard Fischer’s methodology of meta-design [24] could provide pointers for the development of such systems in the respective context. Meta-design methodology seeks to involve users not only in the design process of a system but also as continuous shapers of an initial evolvable implementation: Meta-design comes in three stages as designing for design (i.e. drafting of a system), designing together, which is a learning aspect, and designing ‘the in-between’. The approach is supported through a seeding model, in which the initial system should be ‘underdesigned’ for evolvability, which after a time of use is used to ‘re-seed’ the system in an adapted way [24].

Community rights management would be based on individual privacy rights settings in various public and semi-public places to articulate to users which data would be shared for location-sensitive community development purposes. Similar to the thinking in literature on crowdsourcing, ubiquitous computing infrastructure would provide a generally accessible portal to such community data. This part of the system would not be based on advertising or other commercially focused model to finance the data management but instead rather be financed through public money or directly by the users involved.

Places need to indicate the presence of particular sensing technologies and provide clear data handling policies as citizens navigate the complex amalgamation of public and private digital ‘realms’ in the city. Privacy certification services similar to fair trade labeling for food would guarantee compliance and increase trust. Langenriech [32] provides an early privacy control system which relies on user-set privacy policies on a ‘privacy assistant’, which negotiates data sharing with corresponding ‘privacy proxies’ for each ubiquitous device close by. It is arguably important for particular places to implement standards-based interfaces according to particular locations in a service-orientated manner where different stakeholder groups (community-managed localities, public authority requests, and 3rd party services) announce their data needs to the user simultaneously based on preferences set in a personal data store that governs which data to share, where those preferences could evolve with an individual’s mobility pattern.

A challenging case in community rights management exists in the presence of perceived threats: Sakaki et al. [47] present a system that facilitates the analysis of Twitter messages for emergency response in Japan. This implies that there may be cases for management and accessibility of data on a larger geographic scale – a case for which the benefits need to be carefully considered in the general case if it means a loss of local autonomy and a possible power shift towards other stakeholders external to the local community.

CONCLUSION

The future of ubiquitous computing as an infrastructure is being shaped today in our neighborhood and its principles of design have the potential to transform society. It is the way in which ubiquitous computing technologies are managed, combine, and exchange data, which will influence whether our society will mainly be led in a top-down manner by businesses with private interest, which occasionally clash with the interest of local communities, or whether ubiquitous computing technologies succeed to position themself in society in a manner, that empowers individuals as the central part of the system with full ability to make own choices.

We strongly recommend that as new ubiquitous computing concepts such as social and urban computing are being proposed, which aim the integration of data from sources as diverse as web data, environmental sensors, and mobile phone devices, it is important to take a step back and consider the effect of such data syndication and the array of special use-cases, in which different combinations of data syndication may make sense. The urban process was highlighted to facilitate the discussion on how the balance between the collective of individuals (society), functions of administration (public authority) and commercial interest (such as businesses) could be used to help towards making crucial design choices.

We point out that for the level of transparency of the infrastructure, in the future it is important to consider the usage
of data items shared. Democratization of ubiquitous computing starts with the acceptance and the assumption that personal data collected through ubiquitous devices needs to be put in control of the person and communities originating it, which requires conscious reflection where top-down sensing can actually be achieved by local control instead. As individuals away from home leave more traces behind while interacting in public environments, we need to think about ways to show to residents what data is collected and for which purpose by indicating it at the particular location to differentiate between those parts of the data traces that are to be used for commercial interest and community data, which are data repositories needing to be managed not by an individual, but rather by the collective of the people for example in this particular area.

We call for research in ubiquitous computing which seeks to understand how non-experts could collectively administer ubiquitous computing infrastructure and the data that originates from localized devices. We highlighted metadesign as a potential framework on which ICT tools for community empowerment could be built. Furthermore, initiatives in the field of participatory sensing and open data provide pointers for such a research agenda. This brings people back into control of their personal ‘data shadow’. While individual data privacy is in dynamic interplay with the digital society, making the infrastructure accountable through local control can garner support, open up interesting design choice inspirations, and enable society to reap the benefits from this next-generation infrastructure.

ACKNOWLEDGEMENTS
Thanks go to Monica Büscher, Drew Hemment, Bethan Owen, Maria Terzi, and Stephen Wattam for helpful comments. This work is partly funded by the Digital Economy program (RCUK Grant EP/G037582/1) of the UK.

REFERENCES
3 Bell, D. and Dourish, P. Yesterday’s tomorrows: notes on ubiquitous computing’s dominant vision. PERS UBIQUIT COMPUT, 11, 2 (2007), 133-143.
7 Brabham, D. Crowdsourcing the Public Participation Process for Planning Projects. Planning Theory, 8, 3 (2009), 242-262.
12 Caceres, R and Friday, A. Ubicomp systems at 20: progress, opportunities, and challenges. pervasive computing (2012).
22 Dourish, P. Re-Space-ing Place: “Place” and “Space” Ten Years On. In CSCW’06 (2006), 299-308.


33 Leahu, L., Sengers, P., and Mateas, M. Interactionist AI and the promise of ubicomp, or, how to put your box in the world without putting the world in your box. In UbiComp'08 (2008), 134-143.


