Made-up Rubbish: Design Fiction as a Tool for Participatory Internet of Things Research

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As Internet of Things technologies become embedded in public infrastructure, it is important that we consider how they may introduce new challenges in areas such as privacy and governance. Public technology implementations can be more democratically developed by facilitating citizen participation during the design process, but this can be challenging. This work demonstrates a novel method for participatory research considering the privacy implications of IoT deployments in public spaces, through the use of worldbuilding design fictions. Using three fictional contexts and their associated tangible design fiction objects, we report on findings to inform transparency and governance in public space IoT deployments.

Keywords: Design fiction; internet of things; transparency; governance

Introduction

Increasingly, our environments are being populated by networks of connected devices such as sensors and actuators constituting the `Internet of Things' (IoT). Many IoT products are consumer devices (e.g., smart appliances and virtual assistants) purchased by customers and installed in private spaces. However, IoT technology is also deployed by civic bodies in public spaces (e.g., environmental monitoring and connected transport infrastructure), often tied up in the narrative of the `smart city'. Rhetoric surrounding the use of these technologies on a large scale typically highlights benefits to society, and contributions to health and wellbeing of citizens (Ahmed et al. 2017). As designers, we must recognise the social consequences of these new ecosystems, identify their various stakeholders, and understand who benefits from their deployments. If IoT technologies are to play such a fundamental role in public infrastructure, it is important that their design, development, and use considers their individual and societal implications (Forlano and Mathew 2014).

IoT systems function by collecting data, which can include personal data, and thus risk violating individual privacy norms if they are misused. Concerns over this may be particularly acute when these technologies are embedded in public spaces or take a collective approach to information collection in order to design, implement or deliver public services or provisioning.

Those responsible for designing and implementing such systems may have different priorities than the communities they serve, especially if those communities are marginalised. Legitimacy in governance can be facilitated by granting citizens democratic participation (Weber 2013); thus, it is important that those impacted are given a voice in the development of IoT deployments. Research has shown, though, that participation may only play one role in democratic processes. Communication and deliberation beyond voting and consultation is key to vibrant citizenship and participation of all groups (Escobar 2017). Placing discussion, deliberation and communication early in the design and development process can rapidly identify potential issues and their solutions, both benefiting citizens and reducing the need for costly later amendments.

Citizen participation is, however, often not straightforward, because IoT deployments can be technically detailed, with inherent risks and benefits that may be difficult to communicate and must be carefully balanced. Participation requires awareness and understanding of deployed solutions, and may necessitate explanation of novel concepts and complex relationships between people, devices and the processes of implementation surrounding deployment. We suggest that providing concrete referents to new technologies, situated in a familiar context, is useful to individuals and communities who may not be familiar with its possibilities and complexities. This

increases intelligibility, enabling discussion and deliberation regarding any potential risks, and contributes to developing an appropriate level of transparency.

In this paper we discuss the work of the TrustLens project, building on existing literature on civic engagement, community participation and IoT governance in technology deployments. The project aims to facilitate the design of trustworthy systems by helping citizens understand and interrogate transparency, privacy, and governance issues in relation to public space IoT deployments. We discuss our use of worldbuilding design fictions in combination with ethnographic methods. Design fiction is of growing popularity in design research (Hales 2013), and our key contribution is to evidence its utility as a community tool for participatory work, which can serve dual purposes of new knowledge generation and facilitating inclusive deliberation around complex technological systems (Bergold and Thomas 2012).

Related work

Public IoT Systems

As connected technologies become critical parts of society and infrastructure, policymakers at both national and international levels are paying significant attention to their potential economic and societal benefits, and how and by whom these systems should be regulated and managed (Jacobs et al. 2019b). Media attention has frequently focused on the IoT at the level of commercial services and devices located in the household or other private spaces - for example, the oft-cited smart fridge that orders fresh milk (e.g. Hammersley 2013). However, bureaucrats and policymakers are also welcoming opportunities created by technologies in civic settings, the realisation of which often involves wider scale IoT deployments in public spaces for service solutions (e.g., smart street lighting).

The term ‘smart city’ is increasingly used by policymakers, industry and the media to describe such programmes; however, many have expressed concerns that the term is of limited use, with no consensus definition (Angelidou 2014). Kitchin (2014) suggests that it encompasses two distinct but related concepts; either the building of ubiquitous computing and digitally instrumented devices into the fabric of urban environments, or the broader development of a knowledge economy within a city region, a city ‘whose economy and governance is being driven by innovation, creativity and entrepreneurship, enacted by smart people’ (p2). Such programmes are incentivised at national and local levels, while those tasked with implementing them may have limited knowledge of possible consequences of the entanglements of public provisioning, personal data and community benefit/change (Jacobs et al 2019a).

IoT systems in public spaces are often a potentially more complex landscape for legislation and governance than those deployed for individual use. Individuals may come into unwilling or unknowing contact with public deployments, and as such may have limited agency and choice over their interaction with these technologies (Ziegeldorf, Morchon and Wehrle 2014). By collecting large volumes of data, potentially including personal information, such deployments impact a wide range of citizens above and beyond those who choose to purchase personal devices. Given the serious implications of these technologies in areas such as privacy (Castelluccia et al. 2018), it is necessary to consider and protect citizens’ rights through appropriate governance.

Governance, Transparency and Participatory Methods

Frameworks for data protection and IoT governance often involve transparency and accountability (Almeida, Doneda and Monteiro 2015; Weber 2013) in order to build trust in technology-mediated interactions. Bellotti and Edwards (2004) argue that if a

context-aware system is acting on behalf of users in any capacity, said system must be intelligible - able to represent to users what the system knows, how it knows it, and what it is doing about it. Without such intelligibility of public space IoT deployments, it is difficult for citizens to exercise their rights, and this also applies to their governance processes.

Public IoT deployments which have not fully considered transparency and intelligibility at the outset may encounter issues when the public later gain knowledge of the intervention. An example of this is the Chicago Array of Things, which planned to collect a variety of data (e.g., pedestrian counts, traffic levels, etc.) via devices installed on lampposts (Catlett et al. 2017). Negative press coverage led to public outcry over the city-wide IoT deployment (Jacobs et al. 2019b), resulting in project delays while extensive governance and privacy policies were developed and the IoT devices adapted to address privacy concerns. It is important when developing ubiquitous technology innovations and solutions to carefully consider how they might inadvertently contribute to maintaining existing power structures that disproportionately impact certain groups (Weber 2013). Considerations of intelligibility and control become particularly important here, especially if whether users are aware of the system at all is in question, making intelligibility difficult to assess. Such imbalances may be mitigated by introducing participatory methods (Bergold and Thomas 2012; Forlano and Mathew 2014). Methods involving users as an integrated part of the technology design process, as well as consideration of local factors which impact on social relevance, can be a route to deliberative democracy (Escobar 2017). Effective exploration of potential risks early in the design process prevents missteps such as those experienced by the Chicago Array of Things.

Design Fiction Research Methods

In recent years, design fiction has gained credence as a research method, drawing on a longer history of critical and speculative design movements (Coulton et al. 2017). A key feature of speculative design is that it enables thinking about the future and critiquing of current design practice (Auger 2013). Both speculative design and design fiction are used 'not to show how things will be but to open up a space for discussion' (Dunne and Raby 2014, 51). A key aspect of design fiction is that it includes the use of diegetic prototypes which are physical manifestations of a fictional shift in the world, and may reflect alternate pasts or presents, or speculated futures.

Design fiction has close links with storytelling and narrative; indeed, Hales (2013, 2) argues that 'the convergence of narrative and technology is central to design fiction'. Coulton, et al. (2017) suggest that it is not the fictions themselves that are important, but the cohesive worlds they build in which stories can be told and understood; for example, creating scenarios about IoT objects and their uses. This idea of design fiction as worldbuilding places design fiction objects as 'entry points' into a coherent fictional version of the world which can be examined and interrogated through exploration of its features.

Smyth and Helgason (2013, 78) suggest that 'by using design to develop rich and detailed envisionments of future scenarios, we can make the possible tangible, and offer these possibilities for consideration, reflection and debate'. By opening up discussion space, design fiction worldbuilding can be an important practical tool in participatory research to collectively imagine the 'what if' implications of something that is not true, yet is not entirely fictive.

Our Context

The TrustLens project is investigating factors which contribute to increasing people's

trust in IoT systems, and aims to understand and enable trusted IoT ecosystems by developing computational frameworks for transparency and risk assessment. In order to understand these factors, we are working closely with the community of Tillydrone which has been designated by Aberdeen City Council (ACC) as a regeneration neighbourhood, targeted for particular support due to economic and social deprivation in the region.

In 2017, we carried out extensive ethnographic work in Tillydrone. The researchers joined the 'Tillydrone Network' (an organisation which consists of local residents and key service providers) and attended regular monthly meetings, as well as other community events and activities. A series of interviews were conducted with a number of local residents and key service providers, such as local council members and representatives of local volunteer and charitable organisations. In addition, relevant literature was examined including local newspaper archives, ACC policy and intervention proposals, and a local community magazine. While much of the existing council support and interventions in this community have been enacted through engagement and consultation with the community, consistent delivery and management of expectations has not always been successful, leading to mistrust between citizens and the council. An important function of this ethnographic work was therefore to work closely with the community, and participate in ongoing activities and meetings. Through this, we were able to identify key concerns of the community that might be addressable by IoT deployments.

Developing Design Fictions

Potential risks and challenges of public space IoT systems can be difficult to understand in abstract, since they encompass multiple actors, technologies and types of data. Tangible examples are important for allowing users to identify concerns that may only

be exposed through experience of using and interacting with a system, as well as to understand the community and governance needs that drive such deployments. Therefore, to undertake participatory research to explore key issues surrounding IoT deployments, the project required concrete examples of these, with which residents could connect personally. These would form the basis for narrative discussion detailing not only what happened in the past, but what might happen in future, and alternative possibilities of what might happen in the present. One method of achieving this might have been for the project to deploy prototype devices in the area. However, this would have been limited by the project resources and potential ethical concerns, particularly since the work concerns exploring sensitive issues such as privacy violations. Such a small-scale deployment would also not have been able to replicate the multiple complex relationships of stakeholders affected by public space IoT, and would have been limited to technologies accessible to the project team. Therefore, we took an alternative route of creating worldbuilding design fictions, situated in a near-future version of Tillydrone. In this way, the project aimed to combine design fiction and participatory research. By creating fictional scenarios and objects that arise out of residents' real desires and needs, we aimed to stimulate collaborative, deliberative thinking while mitigating risk and lessening exposure to potential harms such as compromised privacy.

Based on prior ethnographic work in the community by the team, and information and recommendations about community needs detailed in local authority reports (Aberdeen City Council 2017; Tillytattle 2016), we compiled a list of issues relevant to the community. This was important because in order to create a plausible and relatable fictional world, it is necessary to link it to referents with which the audience can relate, and which apply to their own context and lived reality (Auger 2013). From ten identified clusters, we selected waste, litter and dog fouling as a

collection of issues to focus our work, as these themes occurred most commonly across all sources, and are areas in which existing IoT technology solutions are being applied in other localities (Perchard 2017).

In order to develop initial context for the design of the fictional solutions, we examined existing waste services in Aberdeen as well as existing and proposed IoT solutions for similar challenges. We then led the TrustLens team in a series of design sessions, with the intention of developing three hypothetical IoT deployments to provide potential solutions to community issues that might be implemented given no restrictions on resources such as time or cost. The resulting deployment plans were not intended to be extreme speculations, but complete narratives of near-future implementations using plausible underlying technology and solutions. These were described by the team as 'Not beyond the realms of possibility, but beyond practicality for the project.'

For each scenario, the technical features of the fictional device or system itself were considered first, identifying sensors which could be used by devices, and their purpose(s). This was conducted alongside worldbuilding of the context, which included consideration of the speculated reason for each deployment in the setting, identification of intended beneficiaries and users of the system, and identification of organisations which might be involved in the manufacture, installation or management of the system. This activity resulted in prototypic 'design specifications' for the three systems.

The second stage of the design process was consideration of technical functions including identification of the pathways through which data would be collected, processed and used. To illustrate this, a data management map (See Fig. 1) was created for each scenario.

Figure 1. Data Management Map of Design Fiction Scenario 1 – Communal Household Waste Bins.

Based on the device specification and data management maps, we created design fiction objects to act as 'entry points' for interaction and deliberation with the worldbuilding to represent a physical expression of the world established by each fiction.

Design Fiction Scenarios

Scenario 1: Communal Household Waste Bins

An oft-cited issue in Tillydrone is vandalism and misuse of communal rubbish bins provided for residents of the residential tower blocks, which are centrally managed and have a high proportion of social housing tenants. Issues include overfilling by residents and non-residents, and fire risk.

In this scenario, ACC contract a private company 'BinTech' to provide new 'smart bins' equipped with a range of sensors including ultra-sonic measurement of fill levels, a smoke detector to alert in the case of vandalism via fire, and GPS to record the location of the bin. In addition to this, electromechanical switches lock the bins for access only via the use of a contactless RFID access card, issued to residents of the high-rises. The bins continuously transmit data via the free public Wi-Fi network. Data are visualised in a data dashboard, to which BinTech provides ACC Waste Services access, which is used to manage the emptying of bins. This enables rapid response in the event of abuse of the bin, and more efficient collection of refuse based on actual fill levels.

Design fiction objects (Fig. 2) created for the workshop consisted of three entry point items around which participants could construct a narrative: A letter that they

would have received as tower block residents from ACC informing them of the new bins and their installation dates, an access card to be used to unlock the bins, and an FAQ leaflet (containing images of the new smart bins) as distributed by ACC to offer information about the installation, purpose and function of the bins. Realism was incorporated into the documentation by basing it on similar communication recently distributed by ACC in reference to a new city-wide recycling scheme and associated replacement bins.

Figure 2. Design Fiction entry point objects for Scenario 1: Communal Household Waste Bins

Scenario 2: Public Waste Bins

Public waste bins are distributed throughout the Tillydrone area, and are emptied regularly by ACC; however, littering is still a major issue. The second scenario imagines replacement of these bins with 'smart bins' (Fig. 3) that include ultra-sonic measurement of fill levels, a smoke detector to warn in the case of vandalism via fire, and a perimeter LIDAR environment sensor to detect when litter is deposited in the area surrounding the bin rather than inside it. In addition, the bin includes a WiFi and Bluetooth sniffer to measure foot traffic by identifying devices such as mobile phones used by passers-by.

These bins were again supplied by the fictional company BinTech, to be managed directly by ACC. Aggregated data is sent to ACC servers every 24 hours using public access Wi-Fi, with immediate alerts in the case of fire, vandalism or when particular fill levels are reached.

Figure 3. Design Fiction image for Scenario 1: Public Waste Bins

For this fiction, the entry point materials (Fig 4) consisted of two newspaper articles, presented in situ on ersatz newspaper pages modelled on two real local publications. The first was on page 13 and heavily based on a press release by ACC; positive in tone, and praising the new bins. The second, which consisted of a front-page image spread and larger page 3 article, raised issues of privacy and expressed concern for and by local residents. In particular, the issue of proximity of a smart bin to a local playground was mentioned, with the implication that private data might be collected pertaining to children and parents. The fictional nature of the articles was highlighted by the publication dates being in the future; one and three weeks after the date of the workshop, respectively.

Figure 4. Design Fiction entry point objects for Scenario 1: Public Waste Bins

Scenario 3: Dog Fouling

One of the most frequent issues raised by residents is dog fouling. The third scenario includes three distinct but interconnected technology platforms addressing this issue. The first is dog waste bins, purchased by ACC from BinTech, which include sensors to detect fill levels. The council makes this information available in real-time as part of its open data strategy, which has goals of improving transparency and participation. The second is a commercial product, ‘Doggo’, for dog owners to track walks and locate waste bins. Customers purchase a GPS-tracker enabled dog collar, and download an associated smartphone app that locates the dog in real-time and records routes walked. The Doggo app also allows users to identify the nearest non-full dog waste bin using the open data provided by the council. Finally, a community app, ‘PooperSpy’ allows residents to report fouling incidents by uploading images of the offence and details of the location.

For this scenario, two ‘entry point’ objects were created. The first (Fig. 5), representing the Doggo device, was a prototypical representation of the product including the tracking device, charging cable, dog collar attachment and a printed user manual. The manual includes screenshots and diagrammatic instructions for use of the device.

Figure 5. Design Fiction entry point objects for Scenario 3: Doggo

The second object was a poster which participants were informed had been displayed in the local area to advertise the community PooperSpy app. Information included was limited to a statement of the purpose of the app (to report fouling), contact information for a community representative, and links to download the app.

Community Workshop

A workshop was held with the objective of exploring community views on public IoT deployments and encouraging deliberation around privacy, transparency and governance. Nine attendees were recruited through the Tillydrone Community Network. These individuals represented local service providers, residents and ACC.

Although intended to be plausible, the design fictions were not meant to be potentially deceptive. In the taxonomy of Coulton et al. (2016) they are ‘identified as design fiction’ and developed as a tool for discussion. The fictional nature of the systems was clearly conveyed to workshop participants up-front before presentation of the materials. However, participants were asked to consider them ‘as if’ they were real. For this reason, the entry point items did not include the full deployment specification, and were presented in isolation, without contextual notes or other explanation. The design process was inspired by community concerns, but it was the project team who

exhaustively ‘built’ the speculated worlds and described all aspects of the deployment (including all actors involved, their motivations, and the data flow through the systems). This full context was not exposed by the entry point materials, which were intended to replicate the aspects of such deployments that would typically be visible to the public. This meant that some details, such as who originated and managed the deployments and their intent, were not initially available to participants.

Participants were split into three groups, each of which was assigned one of the scenarios. Each group were given time to examine the ‘entry point’ objects for their scenario and discuss amongst themselves, and were then guided through a series of questions presented in the form of a worksheet (Fig. 6).

Figure 6. Worksheet

After plenary discussion of the worksheets, the data management maps (see Fig. 1) for the scenarios were revealed, providing additional context not available in the entry points. These illustrated the flow of data collected by the various IoT devices and the identity, ownership and access rights of all stakeholders. An additional short discussion session gave participants a further opportunity to feed back thoughts and questions to the worksheet based on this additional information, with the aim of capturing any change in attitudes.

A final concluding session of the workshop introduced two real-world examples, of relevance to the community, to demonstrate that IoT deployments not dissimilar to the design fictions are already in progress. These were smart energy meters, and a pedestrian and cycle monitoring bollard which was recently installed as part of a wider roll out across the region by the ACC Transportation and Strategy Team (Fig. 7). This latter example was of particular note as its installation had led residents to query its

purpose in local council meetings, since no information about its function or purpose was readily apparent at the location of installation. Participants were asked to contribute (on post-it notes) what they thought were risks and opportunities with these systems.

Figure 7. Pedestrian and cycle counting bollard.

Results

Using NVivo qualitative analysis software, the data resulting from this workshop were manually coded in categories of responses. This data corpus consisted of written worksheet responses from each design fiction group, transcriptions of discussions in this session, and comments and feedback from the discussion of the real-world case studies. Nine topics of discussion were identified through analysis (Table 1).

Table 1. Emergent workshop discussion topics, from least to most discussed

The discussion topics reveal diverse concerns and questions that residents have regarding public space IoT deployments. Some of these included existing areas of interest for the project such as governance, risk and accountability. Participants expressed concern that consultation processes may not have been carried out, or were ineffectual, and this was linked to issues of agency: that residents did not have any say in whether or not, or how, the deployments occurred. A variety of risks were highlighted, including risks to privacy, risk of criminal activity due to data leaks, physical risk from malfunctioning devices, and citizens being negatively impacted by actions taken by government agencies as a result of data collected.

Other topics raised by the participants were more novel. For example, participants questioned certain financial aspects of scenario 1 and its beneficiaries, and

talked about value in the systems and who would benefit. Some participants did not feel that financial profit from use of collected data was inappropriate, on the condition that the money was reinvested to benefit the locality. We also noted discussion of compliance and complacency, and differences in attitudes towards reasons for interacting with IoT systems. For example, while some would be willing to use a system because of perceived benefits, others felt forced to comply or simply did not want to take additional action to opt out.

The most common discussion topic was transparency, which was expected as, since understanding aspects of IoT transparency is one of the key objectives of the TrustLens project, several of the prompt questions related to this topic. Because of the extent and complexity of discussion on this topic, we were able to further define four emergent sub-topics representing different facets of transparency. Some participants wanted information on technical aspects such as data collection and data usage transparency, but a more commonly expressed desire for transparency related to the wider systems and their governance, such as the intent, actors who manage the system and how information is conveyed to the public.

One aspect that was seen in discussion of transparency and more widely was the mode of communication, and how availability of information about deployments fits into a wider ecosystem of education around technology and its implementation by public bodies. There was general agreement that human agents of communication are preferred, and that information must not only be available, but in a form that can be easily understood and is provided at the correct stage of the process. Without this, it may be difficult to meet requirements of intelligibility. A key finding was that participants valued the presence of a knowledgeable, trusted individual who could be

personally contacted to explain the details of the system and its operation, more so than other forms of communication such as printed or digital content.

We found that assumptions are often made in the absence of full transparency. Through the use of the design fiction entry points, participants were able to create their own narratives reflecting their perceptions of the deployments. These were not necessarily 'true' in relation to the worldbuilding of the project team; for example, participants assumed that in Scenario 1, ID cards used to access the bins were linked specifically to individuals, and that information from these was sent in real-time to the council to monitor bin usage. After the data management maps were revealed, participants revised their conceptions of the system and we were able to examine transparency deficits and how provision of different material might have led to a more accurate interpretation.

Several participants indicated that by going through this process they gained a greater understanding of potential opportunities and consequences of current or imminent introduction of IoT technologies to public spaces in their locality. We also found that in subsequent discussions with the community, there was a higher level of engagement and knowledge surrounding issues related to data management and privacy. For example, following the workshop, a third party organisation engaged with the community to investigate the potential for community owned WiFi, and community members commented at Network Meetings that they felt better equipped for this process.

Discussion

The findings reported in the previous section are consistent with an increased focus on transparency in legislation surrounding collection of personal data such as the General Data Protection Regulation (GDPR) (European Union 2016). This supports the

need for transparency solutions, currently in development (Castelluccia et al 2018). Guidance documents on transparency released by the European Commission in relation to the GDPR requires that 'any information relating to the processing of those personal data be easily accessible and easy to understand, and that clear and plain language be used.' (Article 29 Working Party 2017).

By using participatory methods in combination with design fictions based on real community issues, we have provided key insight into community concerns regarding public IoT deployments and wider understanding of privacy and governance implications. At the same time, we avoided potential risks and challenges and delays often associated with real IoT devices pilot deployments, which can be highly resource intensive. Prior research has used worldbuilding design fictions as a prototype for plausible futures (Coulton et al. 2017), design workbooks to illustrate speculative scenarios (Wong 2017) or co-design of design fiction scenarios as a participatory tool (Forlano and Mathew 2014; Nägele et al. 2018). The novel methodological contribution of this work is the situation of tangible, mundane design fiction artefacts within a participatory framework to facilitate co-design of emerging systems and associated governance processes.

Each stage of the method built on sustained prior engagement activities with the community, and emerged from the local context. This meant that the design fictions presented in the workshop were relevant to the experience and interests of the participants, enabling inclusive discussion of the potential issues around deployments of this type. This grounding in real-world problem solving also lent the fictions plausibility and verisimilitude, as did the involvement of a multidisciplinary team in the initial worldbuilding design process. We created a space for participants to generate 'after the fact' questions and insights in the controlled setting of a fictional deployment that does

not generate potential risk or harm. Although fictional in their realisation and some aspects of the technology, the fictions were ‘dull’ and ‘unexciting’ rather than including distracting user interfaces and futuristic interaction. The detailed nature of the fictional artefacts helped create a plausible mundane future. They thus provoked questions relating to issues that real deployments of IoT in public spaces can encounter, allowing deeper engagement with real deployments.

By participating in this process, residents report feeling more equipped to interrogate and evaluate potential technology implementations – an impact seen beyond those who attended the workshop events. This method of participatory research necessitated sustained engagement activities with the local community in order to build a trusted relationship with the research team, rather than a singular intervention. Such trusted relationships are important not just in conducting research, but in the technology deployments themselves. As in many such communities, there is a complex history of interactions with the City Council, and a multidimensional relationship. Although residents may rely on the council to provide services, residents often exhibit mistrust towards the council based on previous experiences, such as frequent consultation that does not lead to visible results, or perceived overpromising of services which is not followed through by action. Data gathered during the workshop reflected some of these tensions, with residents feeling they may not be fully informed on what happens in the local area, and desiring more transparency of processes. There is currently a gap between the information which might be available about such technologies, and that which is desired by citizens.

The design fiction method used here has enabled participants to follow processes through example interventions, and anticipate possible next steps, which offers powerful, cost-effective tools for interrogating the transparency of real deployments.

This applies not just to public organisations, but also third parties involved as part of such systems, for example by storing or transferring data.

Conclusions

In this paper, we have described a participatory method used for conducting research on public space IoT deployments. We have demonstrated a novel practical application of design fiction methods by a multidisciplinary team in a participatory setting. Design fiction, when built on appropriate local contexts and conceived of as part of a worldbuilding paradigm, can facilitate participatory futurecasting by building plausible worlds that can be explored and examined by means of tangible entry point objects. Here we have shown that when these worlds map to plausible future public deployments, they are a useful tool for undertaking participatory research, allowing a deeper exploration of transparency and governance concerns that are difficult for citizens to engage with in the abstract. There are opportunities in this work both in terms of future utilisation of the method we present here, and also the outcomes of the research itself which highlight key areas of transparency, governance and community deliberation. By building on these findings, future work can explore how these factors contribute to trustworthy IoT ecosystems.

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Theme	Questions	Example statements
COMPLACENCY AND COMPLIANCE:	Do people use the system because they are happy to do so, because doing otherwise would require additional action, or because they are forced by circumstance?	*'this has been pushed out to you rather than you opting to have it' (Scenario 1)* *'Once the system was in place, if it proved to be working…I wouldn't give it a second thought' (Scenario 1)*
GOVERNANCE:	How were decisions about deployment of the system made? How is it managed and who is accountable?	*'It doesn't look like they asked anybody – the council are saying 'we're doing this'' (Scenario 2)*
DATA OBFUSCATION:	Is potentially personal identifiable data anonymised to protect privacy, and if so how? Can individuals mask their data?	*'If they're gathering for 24 hours every phone that goes past they can get the numbers they want out the data and then throw away the identifier' (Scenario 2)*
EDUCATION ECOSYSTEM:	How does communication happen around the system and its use?	*'something technical like this still needs human backup' (Scenario 3)*
FINANCIAL ASPECTS:	Who paid for the system, and who gains financially from it?	*'So if you're doing this and I'm not getting any say in the matter…for your marketing and financial benefit, I want to know where that's money being spent.' (Scenario 1)*
HIDDEN INFORMATION	What do people not know, or not even know to ask about?	*'Both articles don't tell you much whatsoever so it makes you suspicious'. (Scenario 2)*
RISK (Cost/benefit trade-offs):	What value is there in using or not using the systems, and who benefits?	*'If you could get into this app and you were a criminal, you could find out..' 'it gives you the dates and everything' 'a robbers delight' (Scenario 3)* *'Automatically being accused of a crime just because you happened to be in the area at the wrong time' (Scenario 2)*

AGENCY:	What choices and options are available to the users regarding use of, or control over the system.	*'if that's what we have to do that's what we have to do' (Scenario 1)*
TRANSPARENCY:	Data collection transparency: How do the sensors work, what data are collected, why are data collected, who is collecting the data?	*"I would like info on what data is collected" (Scenario 1)*
	Data usage transparency – Where do the data go, how are data used and stored? Who has access and who owns data?	*"The raw data must be logged somewhere; who's got access to the raw data?" (Scenario 2)*
	System transparency – Can the system extrapolate information, who designed and is managing the system, who made decisions about the deployment?	*"They must have to do some kind of consultation to find out if it's worth pursuing. But it's not clear they have done that. Maybe they're not totally transparent" (Scenario 2)*
	Communication transparency – Has information been intentionally withheld? Is the correct amount of information available, in 'plain English'? Are there opportunities to have details explained?	*"You get this through the door it's telling you nothing. It's just telling you you're getting a card" (Scenario 1)* *"If they failed to tell you one thing, what else might they not have told you about" (Scenario 2)*

Table 1. Emergent workshop discussion topics, from least to most discussed