Connecting Citizens: Designing for Data Collection and Dissemination in the Smart City

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Abstract. This paper presents two case studies of citizen data collection and dissemination applications, developed for or by three different local authorities in Northern Europe. These case studies highlight the challenges in meeting the goals of Open Data, of involving citizens as sources of information, and of engendering and maintaining trust as a service provider all at the same time. The challenge of making data open can be seen as at odds with protecting the privacy and safety of citizens when it is sourced directly or indirectly from their actions. Encouraging citizens to collect, curate, and submit data can create misguided expectations of influence over the processes of local government, and disillusionment where action or feedback are not forthcoming. A local authority is trusted to provide information that is verified and for which it is accountable. Balancing this with goal of disseminating the results of citizen sourced data collection activities can result in frustration for developers, users, and local authority employees. In response to these issues this paper presents the following four design opportunities: *probabilistic and personalised representations of data, making accountable the use of collected data, respecting the boundaries of data,* and designing for the *graceful degradation of resources.*

Keywords: Smart city · Big data · Open data · Crowdsourced data

1 Introduction

The conflicting visions of what a modern city should provide for its citizens, and how that provision should be decided upon, targeted, and measured can be seen not only between cities and states, but between and within departments in modern cities. Understanding the differing interpretations of what it means to be 'smart' and what the path to securing a place on the Forbes list of Top Ten Smart Cities is key to being able to understand the behaviour of local municipalities with respect to innovative and disruptive technology.

There has been considerable interest in the opportunities for better data management and collection to improve city functioning. More ambitiously this has been at the heart of arguments for the "smart cities" program, attempts to revolutionise the functioning of city life through technologies of different sorts. Yet these discussions seem often strangely disconnected from the actual practicalities of city activity. Cities governments are still often bureaucratic organizations, with complex leadership structures and conservative attitudes to innovation. Moreover, IT development and management

is often contracted out to private companies, making for complex relationships and incentives for those involved. Indeed, some of the 'smart city' rhetoric is perhaps more about corporations attempting to lock cities into particular technological platforms and vendors.

This paper builds upon previous work in HCI understanding the expectations, and desires, and constraints on the stakeholders involved on all sides of city procurement of new technology [15]. Following on from this work, this paper is structured around two case studies. The first is of a community generated map of addiction and food services, which we use to highlight the challenges of trust, provenance, and branding in the flow of data. The second covers a set of similar, yet independent, applications developed in different cities to support and quantify the increase in cycling as both a health and environmental benefit to citizens. Using these case studies, this paper presents opportunities for design with and for the city fitting with the real-world constraints exposed here and in previous work.

2   Background

Smart City programs typically seek to understand, manage, and improve city functions, often with a top-down approach, through the use of distributed sensing technology and data processing of various kinds. The production of sophisticated data analytics for understanding, monitoring, regulating and planning the city is a key issue underlying the idea of "smart cities" [11] – a vision "for stimulating and supporting innovation and economic growth, and providing sustainable and efficient urban management and development."

Townsend [17] emphasises the role of ubiquitous digital technology in improving how cities function and operate. He describes smart cities "as places where information technology is combined with infrastructure, architecture, everyday objects, and even our bodies to address social, economic, and environmental problems." Yet, he also questions the motivations underlying attempts to transform cities, arguing that "[l]ooking smart, perhaps even more than actually being smart, is crucial to competing in today's global economy", and that such optics may, in fact, be "the real force driving mayors into the arms of engineers." Goldsmith and Crawford [7] point to another challenge cities face in the race to adapt their operations to 'smart' ways of working with technology, where legislation and a rule-bound approach to government becomes an obstacle when working with the vast amounts of data generated by the same technology and by the citizens they serve. They argue for a focus on results rather than compliance to legislation, and on problem solving that combines the city's data with collective knowledge and data generated by the citizens.

Kitchin [11] sees exciting opportunities in cities' move to make use of new data streams to help both governments and citizens to make sense of the city, but he points to serious concerns about "the real-time city", too. These include the politics of big urban data, technocratic governance and city development, the corporatisation of city management and the risk of technological lock-in, system vulnerabilities, and, finally, ethical issues involved in surveillance and control. Building on the "smart city" critiques by Greenfield [8] and Townsend [17] that advocate for grounded approaches that

account for civic everyday realities, Kitchin [11] points out the risk that, without critical interrogation, future "smart cities" may fail to reflect the desires of wider society and, instead, prioritize narrow corporate and state visions.

HCI researchers have presented a range of services that work in the interface between citizens and the city, such as tools for civic engagement that enable citizens to engage with city governance. These include, for example, tools that support civic involvement in democratic processes through situated voting, or invite dialogue around politics of place making [5, 12, 16], and technologies that inform city traffic infrastructure and environmental services with the help of mobile sensing and crowdsourced data [1, 9, 13, 18]. Others have proposed systems for improving the accessibility of the city's services and data, for instance, by supporting interactions between families and case workers when planning parental leave [3, 4], by presenting local crime data on mobile devices to reduce fear of crime [2] or by encouraging smarter water consumption [6]. While this body of work does identify complexities in working with data in city administrations, the main emphasis has been on developing and demonstrating new technologies.

Of particular relevance to our present study are two further pieces that address broader challenges in deploying technology within the public sector: First, Le Dantec and Edwards [14] performed a year-long ethnographic study of ICT use in the public sector, looking specifically at ICT projects that cross institutional boundaries. The authors argue that crossing such boundaries is, in fact, a central part of the work in the public sector. They use the notion of *scale* to describe these boundaries and the complexities they present at different levels: *"(…) cooperative systems with large numbers of users (across independent organizations), and long lifespans (as tools for enacting public policy), and whose use encompasses communities that cross local, regional, and national contexts"*. Second, Harding *et al.* [10] observe that the perceived value and sustained use of technologies for civic engagement has remained low. They argue that prior work has been, perhaps surprisingly, too citizen-centered, and has, as such, failed to account for the needs and concerns of civic authorities whose responsibility it is to ensure the accountability of the produced data. One conclusion from this work is that interaction between the different stakeholders is needed to overcome mistrust and lack of appreciation of the challenges other actors face. They point, specifically, to three key aspects to be considered in design processes: (1) how authorities' IT systems are opened to enable new activities with new forms of data, (2) political and organisational factors hindering transparency, and (3) changes that are needed to work practices within cities to support the development and use of new tools.

3   Method

This paper builds upon a close working relationship with a local city authority in a north European capital city, involving collaborative research projects where the city has provided forums for research, contact to participants, and real word problems to be tackled in collaboration with different city authorities, particularly together with the city's youth services department. Following on from this, we expanded our perspective and collected research materials with a wider scope. We conducted 20 interviews

across five northern Europe cities – interviewing city management, IT managers, contractors and developers. Seven interviewees were managers or staff working in the city government either in front line positions or managing projects that made use of data and software. The other thirteen represented third party developer companies, civic initiatives, and non-profits.

The interviewees were selected on the basis that they had key roles in the development of publicly released citizen-facing applications developed directly by the city, in collaboration with the city, and/or commissioned by the city. The targeted applications had to meet the selection criteria that they were (1) data-centric and citizen-facing, either providing citizens access to city data or producing data to be used in city government in some way, or both, (2) past the project phases of funding, planning and development, and to the point of launch (although not all projects launched). By approaching people in different roles in such projects, the aim was to capture a range of perspectives of how data-driven applications are born, developed and maintained, from planning and strategic decisions to building and practical maintenance.

The interviews were semi-structured and lasted between 40 min and 1 h 20 min. The majority of the interviews were conducted in English. In eight instances, interviews took place in the interviewee's native language (other than English). In these cases, the quotes we present have been translated verbatim to English. The interviews were informed in part by our experiences in working with our city over a period of seven years. This served as an informative background for our data analysis rather than providing specific data for this study per se. The goal was not to find statistically generalizable points, but rather to generate concepts and understandings for working with local authorities. As such, the approach to analysing the interviews drew on an interpretivist stance, with the development of an understanding of the problems and practices of those being studied. The analysis involved open coding of the interviews, and the development of themes through an iterative process of concept development.

4   Future Maps

This section describes the lifecycle of the Future Maps project: a community based project to crowd source local expertise on the availability of services for addiction and food services such as recovery meetings and foodbanks. After documenting the birth and lifecycle of this application this section concludes with design recommendations for other crowdsourcing projects with a goal of integrating with local authorities.

4.1   The Future Maps System

Leveraging community created, local knowledge is one major goal of Smart City projects and the Future Maps system developed as part of the Glasgow Future Cities Initiative was built around this. The project started by recognising that there was a wealth of information in the community around services that support addicts on their path to recovery collected by a charity in a particularly deprived area of East Glasgow.

"They have a map of the services that their users can access. And they've done that map. The problem was it was on somebody's laptop so if he wasn't in the office then nobody knew where to go."

There were a larger number of services to help those recovering from addiction, either official from bodies other than the city authority or services that could be used as such like sports groups or craft classes, that were not displayed for that purpose on the official council, health service, or policing websites.

"There might only be two or three things on the council website or mentioned by the doctor but in reality there is much, much more."

Another issue with the current official data was that it didn't conform to the socio-cultural realities of living in the areas where the services were being provided. The social structure of some parts of the city means that the borders between neighbouring areas are unsafe to cross by residents, and this segregates the services provided by the city based on the geographic territory that they fall into.

"For example DC [sic] and MH are two different territories and people don't go from DC to MH. And MH to DC…So to the city, they've put a swimming pool where every inhabitant has a park within X meters of them. Actually, that's not necessarily true because it might be outside of their boundary."

By providing the local citizens a way to map what they saw as the services available to them, regardless of physical geography, this was a way to provide meaningful data for those in that area and to highlight shortcomings in provision.

Each of the data points initially was of an activity that would be available to recovering addicts as a way to help them stay on track on their recovery.

"If you're going to a recovery café for example, and you can't find it because it's in a big complex then you're just going to the pub and you've made more damage then."

Those providing the data were therefore careful to give detailed descriptions of when, where, and how to get to the activities that had been mapped. They also included photos to help guide the users to the correct place.

But the focus solely on addiction services was something that was seen as a problem of sorts, by those adding to the system and by the city authority. To tackle the social and political issues around this the categories of services on offer were broadened, this also introduced users of services in one category or subcategory to the services available in the others.

"Drug addiction, alcohol addiction and then we had food banks and that made a pretty bleak picture. These are the services that people need. So we made addiction services and made subcategories and then food we had food, we made it food and growing so the food bank and the growing spaces so that they could be the two … And for somebody as well at first they're not going straight for the drug category. They can do something so it changes the perception."

At this point the solution to the problem was technically complete, but there was a lack of technical skill in the community to keep the data updated. This was addressed with a series of training workshops, a manual, and a video. This also had a knock on effect of raising the general technical literacy of some of those involved.

"One of them kept forgetting his password. Because he didn't have an e-mail address he couldn't reset it so somebody showed him how to use an e-mail address and saying at the same time well you'll need one anyway to look for a job."

After training the solution was usable and, to some extent, sustainable for the area in which it was deployed. It was also becoming more widely known within the city authority and within the community of interrelated charity organizations which provide support services for different groups across the city.

4.2   Issues with Future Maps

There were, however, a number of issues with the Future Maps service. Maintenance and expansion were up against a number of barriers. Expanding the scope of the map itself, by integrating other data such as events at sports centres or events at health centres, ran into the problem of boundaries. As discussed in detail in [15], data – and the access to data – is a highly charged issue within local authorities, with the desire for openness directly competing with the safety and control that hoarding data provides. These boundaries are also felt between state organisations, so while the city authority may compile and own data regarding the sports centres in the city, the data on what health and wellness classes are provided at the facilities run by the national health service are separate. These organisations were not willing to readily provide the information to be presented in a way outwith their control, with the express concern that this would have the possibility to tarnish the trust the citizens had in them. Data from other sources, especially crowdsourced data from citizens, presented alongside their official data could be, in their eyes, misconstrued as being official or at least verified by the city or the health authority – meaning any mistakes in that data would reflect badly on them.

Another issue with expansion was funding. This was wholly supported by a charity that received donations expressly to work with addiction in one area of the city – they had neither the resources, nor the ethical leeway in the use of their funds, to support other areas of the city and refugee services when asked by another charity. The city authority was also unable to directly fund expansion of the service as it would then become part of the service provision of the city and fall under government procurement regulations.

Without going through procurement the small agency, which through a small innovation fund was able to work with digitising the map, was unable to provide the manpower necessary to take it further. The charity was able to fund server costs, and saw this as a useful part of the service they provided. However, the changing economic climate and the continual churn of volunteers means that updating and verifying the information became a burden forcing them to, hopefully temporarily, make it only available at their main centre where someone would be available to monitor what data was being accessed and make sure that it matched what they knew of the ever shifting landscape of provision available to those they help.

4.3   Design Lessons from Future Maps

While [15] focused on learning to understand the complex organisational structure within which such applications would find themselves, this paper instead attempts to work within the boundaries and with the conflicting goals of the actors present in local authority development.

The first design opportunity here would be to respect the organisational boundaries in the data. While there is a value to aggregating data from a number of different sources to attempt to present a complete picture this is not the only way to present a number of data sources in order to provide users with all the information that they need. There are a number of ways to provide clear separation in the UI. One is using map layers and different icon sets and providing the data providers the opportunity approve which other data sources their data would be able to be shown alongside (meaning that on selecting a course that was not approved, the data layer would be removed from view). In the case of Future Maps, designing to respect such boundaries may have provided the technical, as well as the political, separation necessary to allow the charity focused on addiction to open the service for other charities with other responsibilities.

The second design opportunity presented by the Future Maps service is to allow for graceful degradation of resources. While graceful degradation is a common design principle with respect to device capabilities, meaning that a website, for example, would still provide a good user experience on a device that did not support functionality the main design takes advantage of. In the case of Future Maps, designing to support the waxing and waning of resources could take a number of forms. One would be to invest significant effort in providing stand alone training resources that would allow the service to more easily changes in administration users without an overlap between them. Another would be to ensure that any online-only services would come with a pre-built solution to allow them to be moved seamlessly between paid-for hosting and to be run on a single computer or laptop in-house. On the user facing side, it would also be important to make visible the age of any data presented and provide the ability for users or admin staff to verify data points – with the same UI features providing accountability and age for the verification.

5   Two Cycling Apps

We are able to compare and contrast two projects with very similar goals across two cities in northern Europe. Both services share the fundamental idea that citizen-sourced data from cycling can be leveraged to inform and improve decision-making on city planning around transport – for the betterment of cyclist and to encourage a healthier lifestyle in each respective city. They are not directed at cycling enthusiasts – instead of providing feedback on performance they invite cyclists to contribute their route data to be analysed. The two apps, although they differ on the surface, have very similar functionalities; they use GPS to enable the user to track their ride from start to end point, calculate distance, average speed and total riding time. This data is then submitted for analysis as a service to the city:

> *"What we provide is digested information out of this, (...) a report or an analysis with some recommendations, perhaps how to improve cycle planning expenditure."*

Although both were successful in gaining users, neither of them have yet succeeded in the goal of influencing the city in a meaningful way. This section draws on their respective stories to illustrate the challenges in working with the city.

BR is an example of an initiative where an external actor has initiated and developed a service in collaboration with the city. As the founder explains:

> *"I'd been thinking about this problem with different modes of traffic for quite a long time, ... it is not really working very well, the cycle planning in part within the transport planning ... I was like, "Something needs to be done.""*

The traffic authorities agreed with the problem formulation and entered into a collaboration to make the service a reality, but over a year after launch the city is yet to use the resulting analysis the way it was intended and effect real change.

> *"We think that you can spend ... tax payer money much more wisely is actually saying to the officers, transport officers, "Actually, you have to change a bit about how you do this and you think about this. ... So that's basically a challenge, to make them pay to do that, to change" – S2.*

This illustrates how just providing data is often not enough to affect positive change within the city. Data ties in with city functions and the processes that make up these functions have to be changed to accommodate any change in the data.

GC, on the other hand, was born from the same Future Cities funding initiative as the Future Maps example above. Although seemingly more straight forward in terms of funding and approval from within the city, the full concept of the service was not actually better grounded. The idea of feeding cycling data back into the city came from the developers themselves:

> *"Yeah, so the spec we have is kind of one paragraph, a cycling app, and that's it. Map usage, cycle usage and we've been at it and we've done what we thought is best."*

This meant that the project had similar challenges as the BR app when it came to making the relevant administrations in the city understand the value of the data and achieving the type of impact on decision-making intended in the design of the service. The flow of data produced by the GC app presented a different set of problems:

> *"(...) we had to work within privacy impact and stuff within the council, be compliant with the Information Commissioner's Office. They would check and double check and treble check and that really slowed progress."*

The city was eager to aid in the production of an app that encouraged cycling, but when they realized that data would be collected from citizens and then shared without being manually checked by a city employee, the eventual launch was delayed by over nine months. The developer interviewed for this study felt the city's concerns were unwarranted.

> *"I think there was a culture of fear around what's going to happen. What if? What if? What if? Which is, again, its insane to have projects that you have constantly fighting against what ifs rather than doing it and seeing."*

To date, neither city has used the data produced by the cycling services in any significant way. The developer of GC expressed frustration that what was discussed when the app was being developed did not match the actions he saw once it was eventually released.

"In all the press releases that was the line they went with. I would like to see it happen. I wouldn't hold my breath on it. If the council doesn't use it it's not like other people will."

5.1 Issues with the Cycling Apps

The two main issues that will be focused on here are the collection and dissemination of potentially identifiable citizen data, and the challenge of influencing city policy with citizen data.

The first issue, that of the risk averse nature of local authorities when dealing with the confluence of new technology and potentially identifiable citizen sourced data brought under their control, is understandable. As noted above, local authorities place a lot of value in the trust their citizens have in them and are protective of that trust. Anything that has the possibility of eroding that trust has to have clear and overriding benefits in order to be successful within the local authority. The fear of data, either leaked or officially released, causing real harm is an ever present worry for those tasked with managing open data provision in city government [15]. In this case, the developer of GC recounted a fear put forward to them of a route being seen to start near a hospital and end near a residential area being reasoned by a person with malicious intent to be the commuting route of a nurse or doctor. This fictional actor would then be able to lay in wait for the health worker to assault them on their way home. In a similar vein, the head of the agency working with Future Maps recounted a problem they had with using user stories to explain how the system worked to those outside the charity organisation. They had used a common first name and a fictional street name to describe each of the fictional users to be used as examples in showing how to use the service, but this was vetoed by the local authority because of the potential reputational harm it may have to someone of the same first name in a similarly named street – if they existed – to link them to addiction services.

Both of these interactions with the local authority help paint the picture of an understanding of data dissemination, its power, and the limited control that the authority has over it which – while not unreasonable – proves to be a barrier for development.

The second issue highlighted by the cycling apps is the challenge of influencing city policy. As discussed in previous work [15], this is partially an issue of differing temporal scales between application developers and city planning and partially to do with a lack of clear understanding of where and how the city would incorporate such citizen sourced data into its planning process. So the issue here is two fold, on one hand there is the issue of providing the data in a format, time, and place for it to be influential to the city and on the other hand there is the issue of making visible the influence that the data has to those providing or curating it.

5.2   Design Lessons from the Cycling Apps

The issues highlighted above could be dealt with by working with all stakeholders to ensure a shared understanding of the goals, risks, invested value, and processes involved [15]. However, each of these issues also presents opportunities for design innovations to meet the challenges from which they are born.

The issues around sharing data that has the possibility to be identifiable or attributable to any citizens can be mitigated by designing probabilistic and personalised representations of the data for each user. In the case of the bike routes, the solution to obfuscating the data was to trim the start and end of each cycle ride in order to make it harder to point to an individual residence or workplace. The issues raised by those in the local authority were, in some ways, valid in that such a solution does not protect users on less well used paths nor those that work or live in sparse areas of the map. A more robust solution would be to provide a probabilistic reimagining of routes as they are shared publicly. In such a display the probability of a cycle route following a particular road would take into account possible other routes on the map, the number of unique users who cycle that route, and the frequency with which that route intersects other detected routes. This would mean that a cycle route off the beaten track used by one person to commute would be unlikely to be shown to others, a less well used route that crossed one or more common routes would be shown with deliberate errors, and the most common routes would be shown without modification. The personalisation of the display would be used to show routes that the user has cycled along in their full fidelity irrespective of the number of others that have used that route.

Designing with the goal of influencing city function is more challenging. One aspect of the frustration felt by the developers, which was posited as a reason that the use of these city-focused cycle tracking applications may drop off faster than the commercial, performance focused competitors, was the feeling that the data was left unused by the city employees that it was presented to. In order to make the use of this data accountable, the developer could focus resources on the interface provided to the city employees and develop methods to explore and interrogate the data. Providing functionality in this service for the city official to mark routes as important, or to export the results of a certain enquiry in a format easily incorporated into internal reports and presentations, would encourage the city employees to work within the system. This use could also be used to provide feedback to the end users from whom the data was sourced, showing them which routes had been receiving the most attention from the city authority and engendering a sense of purpose and progression in the use of the app even if new city infrastructure was still at the pre-planning phase. This mechanism could also be used for the city to announce when projects had been approved directly to those who would feel the impact the most rather than through the standard practice of public yet obscure planning meetings.

6 Discussion and Conclusion

This paper has used two case studies drawn from a larger body of interview based work focusing on technological innovation in cites to provide concrete design opportunities available to developers to mitigate some of the most pressing issues when working in such an environment.

In recommending that developers design to *Respect Boundaries of Data* this paper presents a pragmatic solution to the problems that these boundaries can cause. Breaking down such boundaries may be a worthy goal, but beyond what can be reasonably expected from any development team working within their confines. Designs that respect and expose such boundaries may over time, by raising awareness of the boundaries to citizens and municipal employees not directly faced by them on a day to day basis, erode them to an extent where such a recommendation is not necessary.

Designing for the *graceful degradation of resources* is an important counterpoint to the idea of a governmental contract being a golden ticket. Due to the complex nature of procurement at the local authority level most of the applications we discussed with our interviewees, and all of the ones described in this paper, were not developed to be part of the main service provision of the local authority. They were mostly funded as one-off expenses through innovation budgets of one sort or another. While there was the expectation on the part of many of the developers that a successful system would have the chance to become part of the service provision [15], the only examples of this were the cycling apps where one was brought in-house to be managed by the developers already employed by the authority and the other was spun out as a company to sell data analytics back to the authority as a service. Understanding the chance of limited or changing resources assigned to their application allows developers to design for genuine longevity and continued engagement, giving those services a greater chance of being picked up as part of service provision in the future. In this vein, it is possible to start such projects with the goal of becoming part of the service provision. However, in doing so any design must be done with a clear understanding of the general procurement procedure and any funding specific constraints or opportunities resultant from the innovation funding. Providing a clear path to release and a clear benefit for the citizens may not be enough to secure the projects continuation, or to stop another company bidding to provide a competing system if the value is demonstrated.

Designing *probabilistic and personalised representations of data* is one solution to managing the sensitivity that city authorities have to the collection and dissemination of potentially identifiable information from citizens, but it also provides a general tool for the development of more privacy sensitive crowdsourcing applications.

Designing to *make accountable the use of collected data* can be seen as an opportunity to support and encourage the integration of crowdsourcing applications into city functions while allowing the city to present itself as more responsive and connected to the citizens under its purview.

Taken together these four design principles, based on real world examples of issues faced by developers working with local authorities, can be viewed as opportunities to better develop applications that fit with the realities of city organisations. They can benefit not only commercial developers, but also researchers using the city as a testbed.

As cities increasingly move towards introducing technology and data driven solutions as part of their service provision, more and more small scale research and private exploratory projects can be expected to be funded to explore the options available to them. This paper provides concrete recommendations for these projects going forward.

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