Urban Data Solutions for a Thriving Smart City

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Abstract

This research note proposes the 'Thriving Smart City' as an approach to reframe thinking along a more ecological view of the smart city. We discuss urban data focused solution development and co-creation approaches to addressing the Smart City imperative in context of the EU H2020 Organicity Project. Organicity is a funding and support mechanism for experimentation with urban data, using a core principle of co-creation and real-world experimentation in its offering. We present some initial learnings emerging from our case study on Organicity in terms of the value and challenges of co-creation and experimentation support mechanisms for cities, as well as considerations for other researchers co-creating and experimenting in the city.

Introduction

Towards a Thriving Smart City

'Smart Cities' as a paradigm evolution in thinking from 'sustainable cities', 'intelligent cities', 'Digital Cities' etc. have a multitude of definitions and understandings across domains(Green, 2016), though most consider the role of innovation in technology, the environmental requirements, the economic and social development (Cocchia, 2014) and advances in governance as central. Whilst 'Smart Cities' can be seen as cities with a capability for change, aware of itself and its surroundings, and intelligent in how it responds, with the ultimate goal of quality of life (Maccani, Donnellan, & Helfert, 2014), it seems to envision what a city should be without emphasising the characteristic or condition of how it should be.

The Oxford English dictionary defines 'thrive' as to develop, prosper or flourish, it's furthermore been defined in terms of being 'alive', having 'vitality' and 'doing well' (Oxford English Dictionary, 2017). In the context of an organism, we look beyond survival, to conditions of thriving. In the context of cities, cities may need to adapt to environmental, economic, social *issues* to function or survive, but they may also be seen as an *opportunity* to gain vitality or thrive. 'Thrive' is a thus a different conceptual lens with which to characterise the kind of condition of cities we seek. Whereas 'sustainability' emphasises continuity, 'resilience' emphasises recovery, 'digital' emphasises technology, and 'Smart' emphasises intelligent, we should also turn to 'thrive' to emphasis prosperity or vitality. Reviewing cross-domain definitions of thrive which focus on state, process or outcome, we combine these to (Brown, Arnold, Fletcher, & Standage, 2017) define 'Thriving' as the joint experience of learning, development, success and vitality. By joint experience we mean that all actors (individual, group, community and organisational etc.) learn and develop, reach desired goals, as well as experience prosperity and 'aliveness'. For example, for democracy to flourish and not just sustain, active citizen participant is needed, for governance to be effective and prosper, the benefits of digital transformation is called upon, and for the natural environment to thrive the ecological ecosystem needs to be understood and supported etc.

In the context of Smart Cities, the concepts of 'Sustainability' and 'Resilience' has increasingly been refashioned for a 'human' centred perspective, without sufficiently acknowledging the ecological ecosystem of a city where both humans and the remaining ecological environment inhabit (Nelson, 2008). Whilst concern for the quality of life of citizens has encompassed how their city environment makes a city liveable and healthy for humans, less attention is shown with regards to making the city environment holistically flourish onto itself, and how we should understand and ensure this. This can be framed theoretically as 'Ecological Modernisation' (Jänicke, 2008) as opposed to a 'Deep Ecology' (Nelson, 2008) perspective, where Ecological Modernisation focuses on how improving the environment ultimately benefits humans, and 'Deep Ecology' positions humans significance amongst the larger ecosystem. To shift our thinking closer to a 'Deep Ecology' perspective in how we focus on the Smart City, means to focus on how all actors (including non-human) are considered, and where 'vitality' not just 'intelligence', resilience and sustainability are stated goals. Thus a 'Thriving Smart City' is aware, intelligent and responsive, sustainable and resilient but also imbues vitality both culturally, environmentally, socially, politically and economically.

Whilst the Information Systems field has taken up the challenge of Smart Cities, to 'change our ways of interfacing with urban space' (http://iass-ais.org/proceedings2014/view_lesson.php?id=116) through the use of IoT, urban

big data (Pan et al. 2016) and advanced analytics and insights (Rizk, Bergvall-kåreborn, & Elragal, 2018) etc., by focusing on contributing and establishing the relative vitality etc. of the city through data, we begin to extend the focus of what data is needed, how and where that data is captured and what insights communicated. For example, whereas air quality data can inform cities and citizens of pollution levels across the city, and sound data can establish noise levels, or specific anthropogenic sounds from both humans and wildlife, how does such data be combined to result in insights on the vitality of cities? How should the vitality of a cities wildlife be captured and communicated to cities and citizens? And what role do citizens have to play?

Urban Data for a Thriving Smart City

Whereas the paradigm of 'Smart Cities' (as a response to increasing urban population, environmental pressures, budgetary restraints, legacy IT systems, ongoing city developments and renewal, as well as policy & rationales for bottom up citizen engagement & participation) has opened new possibilities for urban data focused social innovations (innovations with public good) and innovative business models, emphasis has thus far been on addressing significant city challenges, and not necessarily in exploring inherent opportunities. Thus, innovations tend to proposition urban data focused technological solutions as a response to pressing urban challenges and digital transformation imperatives. Here, we define 'urban' as 'relating to a town or city' (Oxford dictionary). Reviewing existing definitions of 'Urban Data' (e.g. Wolff et al. 2015) and 'Urban Big Data' (e.g. Pan et al. 2016) , we define Urban Data as, data concerning one or more town or city spatial region(s) physical, social, cultural, political or economic environment. Thus, Urban Data is about a town or city region(s) citizens, its wildlife, its infrastructure, its businesses, government and physical environment etc.

Importantly, the nature, type, structure and quality of urban data as well as its combining heralds challenges in its capturing, storing, processing, analysing, eliciting insight and ultimately communicating and actuating. In Europe, there has been much effort at developing new technologies and techniques from cloud storage, Lora and 5G, IoT, to API's, Platforms, data models, standards, visualisation techniques to modes of interaction, in order to realise sustainable ecosystems of urban data driven solutions with public and/or commercial value (Universitet, 2017). However, identifying value from urban data, as well as maturing the technologies to realise cost effective, sustainable and scalable solutions has been fraught with barriers and challenges. Social, technological, ethical, legal, industrial, financial, typological barriers and challenges can only properly be identified and overcome through careful research and experimentation involving a diversity of stakeholder expertise and insight. Furthermore, the emergence of new and complex urban data driven cyber physical systems, products and services, requires new methodological approaches in design, development, testing through to fruition of sustainable and scalable solutions. Hence the 'Living Lab' (Maccani, Mcloughlin, Prendergast, & Brian, 2017; Mcloughlin, Maccani, Prendergast, & Donnellan, 2018) approach with its emphasis on 'co-creation' and 'real world' experimentation is seen as crucial (Cosgrave, Arbuthnot, & Tryfonas, 2013) in overcoming such complex challenges, but also as a normative approach whereby citizens and other actors are considered into the nature and character of artefacts in cities that affect their lives, and the nature and character of the city they wish to be apart of.

Co-Creation

Within the paradigm for Smart Cities, Co-creation has been argued as vital in realising the Smart City (Schaffers et al., 2011). Co-creation has been cited as a necessary good in itself, and/or as an outcome focused mechanism in terms of delivering insights, risk aversion, effectiveness & efficiency, democratisation, or social capital etc. (Mcloughlin et al., 2018). At its very basis, co-creation is about emergence or creation when two or more actors come together. For example, writers collaborating on a song, or the manifestation of a story co-created through the author of a book and the reader of a book. No two harry potters were ever imagined exactly the same! From an economics perspective, Toffler (1980) noted that (at the time he was writing) consumers could make long-distance calls without asking a operator, administer their own pregnancy tests instead of relying on a doctor, and pump their own gas instead of expecting a gas station attendant (Toffler, 1980). Here, co-creation started to be theorised as an economic principle in production, where value (e.g. calling long distance relatives, pregnancy results, or a full tank of petrol) may be partly produced and positioned beyond the organisational boundaries. Recently, Von Hippel & Chesbourgh further theorise this evolution in business as the move to User Innovation (von Hippel, 2005) and Open Innovation (Chesbrough, 2003) strategies respectively. Taken together, co-creation has been conceptualised as both the co-invention (or user involved innovation) of a product or service, or co-production where end users are part of the value creation in ongoing product or service delivery. In the context of public services, Voorberg et al. (2014) distinguish three types of co-creation which differ in their degree of citizen involvement. (1) Citizen as 'co-implementer' of public services. For instance, citizens separating types of garbage for disposal. (2) Citizen as 'co-designer' where citizens influence how the service is being designed, and

citizen as (3) 'initiator' where citizens themselves are supported by the city in taking the lead. For example, citizen science experiments and 'campaigns'. Through combining real-world experimentation with co-creation, barriers and challenges in the design and delivery of innovative smart city solutions can be supported, whilst humans and non-humans become key actors to realising a 'Thriving Smart City'. For example, wildlife in their natural habit become integrated in the real-world experimentation process, whilst insights gained from sensing the wildlife of the city may become valuable to understanding and predicting the environmental conditions of the city. In sum, the living lab approach with its emphasis on real world experimentation and co-creation better factors the non-human into the co-creation of the city.

Following the above discussion on defining a thriving smart city, the role of urban data and approach of co-creation, we next discuss the case of Organicity (Organicity, 2018). Over its lifetime it has enabled and supported experimentation of 40 new urban data driven solutions that address pressing 'Smart City' challenges (these challenges are formulated through stakeholder involvement including citizens, and thus are not necessarily top-down prescribed). First we introduce the H2020 Organicity Project as a case, and our method of data collection and analysis. We then discuss initial insights in terms of (1) highlighting the benefits with which initiatives like Organicity can bring for the city, (2) survey the diversity and flavour of use-cases it supports, (3) touch on the value and challenges of co-creation in developing solutions as well as (5) key challenges which 'experimenters' have thus far experienced when doing real world experimentation in the city.

Case and Research Design

Organicity is a cross-European funding, support and IT capability mechanism for experimentation of new urban data focused solutions that address pressing city challenges. Its model is an 'Experimentation As A Service' facility. In essence it's a federated 'Living Lab' infrastructure across several European cities (e.g. London, Santander, Aarhus) with the goal of enabling and supporting innovative urban data driven solutions ranging from environmental pollution monitoring to new forms of citizen engagement. It works with cities in defining city challenges to fund, with a core principle of 'Co-creation' and 'Real World Experimentation' in funding and supporting the defining of problems and the reaching of solutions. The rationale for its federated multi-city support and 'living lab' flavoured principles are to encourage the sustainability and scalability of the solutions emerging. Furthermore, it supports experimenters with a tool-kit of both IT capabilities that can aid experimentation as well as privacy, ethical and methodological guidance in carrying out experiments. In this regard, Organicity has gone through two open calls to fund and support over 40 European 'experimenters' ranging from Start-Ups, SME's to grassroots movements in ideating and developing prototypes that acquire and leverage urban data. Many of these experiments develop or leverage IoT, mobile and web apps, soft sensing interfaces and open data.

In case-studying Organicity, we've interviewed over 30 of the 40 experimenters, interviewed city stakeholders across London (N = 8), as well as collected and analysed experimenters initial applications, reports, blogs, and publicly available information, as well as city policy strategies and Organicity reports. This helped us to understand both (1) Organicity and (2) the ecosystem of organisations and their journey of experimentation in developing the solutions. The data collected and thematically analysed contributes to our understanding of (1) approaches and methodologies for co-creation (2) sustainability of Organicity as an EaaS facility, (3) factors and barriers in 'Co Creation' and 'real world' urban experimentation, (4) factors and barriers in developing a European urban data driven ecosystem, and a (5) typology of urban data driven business models.

What follows are initial insights concerning the analysis of the first open call of experimenters in 2017. These were thematically coded using MaxQDA with examples of 'experimenters' (i.e. Leapcraft, Colour in City, Wayfindr, Tranquil City, Public Like Displays, FSTR, Airpublic, Empati, Green Roof Monitoring, Edinburgh City Sounds) presented to illustrate learnings.

Initial Insights

Evidence base through experimentation

We found that in terms of Organicity and it's 'ecosystem' unleashing value for the city, cities repeatedly refer to (1) the need for a solid evidence base in order to influence policy and secure funding for initiatives, as well as (2) the need for the 'open data' they generate to be exploited and contribute to new economic growth. In this regard, Organicity supports grassroots led movements in gathering urban data to unleash new insight. What Voorberg et al (2014) refer to as 'Initiators'. For example, the grassroots led experimenters, 'Tranquil City' collected qualitative data to identify the areas combining low noise and air pollution in London in order to provide

alternative routes for travel and leisure commutes. They crowdsourced tranquil spaces by organising city group walks where citizens use social media to define and tag tranquil spaces. This experiment resulted in an open dataset of over 180 points that could potentially benefit, (1) city planners, (2) a business's commuting app offering (3) citizen renting / buying choices, and (4) is available on the Organicity digital platform to complement other future experiments. Importantly, taking a qualitative approach to tranquil spaces, meant citizens have a say in defining peaceful, healthy spaces. Thus, unlike an IoT sensor, citizens can sense and define a tranquil space by any criteria they wish, that may concern a combination of factors converging. 'Colour in City' also took a Social Innovation approach to ascertaining new qualitative data-driven insights related to well-being issues of parents living in overcrowded housing. They achieved this by developing a chatbot service delivered through Facebook. This resulted in recommendations for the London Economic Action Partnership (LEAP) and the council where the experiment was run. The rationale behind a chatbot is to allow individuals use their own voice and meaning to communicate, and to do so in a convenient way. In both projects citizens potentially benefiting from these experiments actively co-created throughout the experimentation and were informed of results.

A key insight from use-cases of experimenters in the first round of Organicity funding concerned the need for additional sources of data which enable or provide added value to experimenters solutions being realised. In this respect, by enabling and supporting one-off experiments to release new forms of city data, Organicity supports the capability of urban data / IoT focused enterprises and more broadly enriches the urban data ecosystem with which to develop city data markets. Furthermore, the capability of a city to support citizen and grass-roots data driven experiments leveraging advances in data capturing devices (i.e. smart-phones, IoT) to gather evidence to support change is currently lacking. Mechanisms like Organicity provide a unique capability for achieving active citizen engagement that brings together all stakeholders throughout the process. Through the lens of a 'Thriving Smart City', unleashing new sources of data from a bottom-up perspective, enables citizens to get involved in setting the opportunities and challenges of a city through the types of data deemed important.

Value from Co-creation and Real World Experimentation

Organicity's first open call demonstrated strong interest by SMEs and Start-ups in leveraging Organicity to advance solutions from mobility, social-welfare to environment, city planning to procurement etc. It showcases the value of new city data through proposed solutions. For example, both 'LeapCraft' and 'AirPublic' developed multi-city experiments to prototyping and validating mobile air-pollution IoT sensors at significantly lower cost per unit, whilst increasing the spread of air-pollution measurement points and reducing the cost of deployment. They achieved this by focusing on mobile assets that traverse the city on any given day. The experiments also exposed existing challenges such as needed 'cooperation and coordination from city councils', challenges in 'access to city assets', as well as navigating differing city typologies in validating use-cases. In both cases, the typology and infrastructure of the city became an important factor in the experimentation process. In the case of Leapcraft, the challenge extended to effectively communicating air pollution data to citizens in public spaces. Thus, citizens were vital co-designers in the process.

Green Roof Monitoring is an Oslo based experimental start-up conceived through citizen experiences of extreme weather events, and changing city policies. It aims to use urban data (captured through IoT and other sources) to assess the health of Green roof coverage in the city. Yet to be explored is how the data captured is produced into insights and communicated to citizens. For example, the challenge will be how to bridge the gap between visualising the current health of a green roof, and what citizens must do to ensure the health of a green roof. In the context of a 'Thriving Smart City', how can such insights also inform ensuring biodiversity of green roofing? Extending beyond Green Roof Monitoring, how can urban data also inform a permaculture approach to the city?

In Scotland, Edinburgh CitySounds captures sounds by installing 'Auditory' data 'Sensor' Devices (AASs) across the city. These AASs capture short clips of ultrasonic and audible noises of bats, birds and other wildlife, traffic, and human activity in real time. These sounds inturn are combined with other data sets such as light, temperature, humidity, pollution to answer questions pertaining to the impact of human activity on animal behaviour, changes in human/animal behaviour with exogenous variables etc. Like many of the experimenters we've examined, it is key how Edinburgh CitySounds develops visual standards to represent these seemingly unstructured, inconsistent, incoherent data sets, in doing so greatly enhance the value of its approach. In the context of the thriving Smart City, it is interesting to contemplate how cities can move beyond sensing wildlife to communicating in real-time with wildlife, for example using sounds to warn wildlife of night-time fireworks, give advance warning on torrential flooding. Thus, can the Thriving Smart City effectively communicate with its environment?

In terms of value from 'Living Lab' focused experimentation, Organicity's emphasis on a co-creation approach to solution development led to activities that had a substantive impact on experimental outcomes, including user

insight led refinement of urban data visualisation (e.g. Public Like Displays; Leapcraft), the crowdsourcing of geo based datasets (Tranquil City), user centred design of a soft-sensing IoT probe (i.e. Empati), Generation of 'Chabot' app and qualitative dataset (Colour In City), a mobile air pollution IoT proof of concept (Airpublic), hackathon development to achieve an API and ITU accredited audio navigation standard (Wayfindr) and an adjusted carpooling service offering based on local city typology and culture (FSTR) etc. In the case of Wayfindr, they combined real world user testing with a competitive hackathon organised as a two day event. By pairing visually impaired users trialling an audio navigation app and navigation standard with teams of developers, users gave feedback in cycles to hackathon developers iterating an API, standard and App on the fly. In the case of 'DoitKits', they relied on an extreme river flooding event in order to capture the data they needed to test their water sensors.

Challenges of Experimentation

Developing for the first time novel urban IoT/data solutions under the support of Organicity, led to significant learnings by experimenters in ensuring co-creation focused experiments that best addressed city challenges identified. These included sometimes inter-related issues of; time, budget, communication, stakeholder-recruitment, access, as well as suitable co-creation methods employed:

In terms of time, themes emerged in terms of overcoming time constraints of experimentation whilst staying within budget, and ensuring co-creation activities could be organised given specific time constraints/availability of stakeholders, such as city officials and companies (e.g. FSTR). Closely related to the issue of time was available budget, whereby a challenge was ensuring suitable co-creation activities could be organised given significant financial constraints of small start-ups and grass-roots organisations. In some cases, experimenters cited this constraint as influencing and prioritising the type of co-creation activities undertaken (e.g. Wayfindr discussed below). For some, ensuring recruitment of stakeholders (particularly end-users) formed a key consideration. For example, FSTR refined how they recruited students for their co-creation workshops to include intermediaries and social-media platforms based on initial poor response. In terms of communication, experimenter's ability to best engage with end-users or other stakeholders through co-creation activities was seen as a challenge they worked to overcome, such as the case with Empati who initially designed mock-up's of their solution to engage citizens on intended prototype deployment. Furthermore, having suitable mediums of communication with stakeholders emerged as a challenge, for example in terms of ensuring stakeholder input via such means as VoIP where necessary. Access, both in terms of access to facilities or city assets, and in ensuring access by end-users with special needs, resulted in key learnings which experimenters felt could be applied to future experimentation. For example, given time and financial resource constraints, Wayfindr organised a two day co-creation activity with visually impaired users in order to evaluate and iterate an audio navigation solution for the London underground. Wayfindr experienced challenges in securing both the location with TFL (Transport for London), as well as ensuring their visually impaired users were suitably catered for. Finally, several experimenters referred to evolving and even developing new co-creation methods through the process of experimentation as needs arose. Whilst some experimenters referred to the challenge of ensuring co-creation activities were sufficient in scope and number. Others referred to unexpected co-creation activities emerging. For example, Leapcraft referred to unexpected extensive dialogue with partner bus companies in negotiating access, installation and experimentation of air pollution sensors across the three European cities involved. Thus, although many of the experimenters had previously been involved in formal or informal co-creation activities, the specific nature of co-creation focused experimentation in the context of urban IoT/Data solutions led to unforeseen challenges being negotiated. Furthermore, running multi-city experiments created additional unforeseen challenges in terms of such issues as planning, distribution of available resources, access to gatekeepers, end-user visualisation and adjustment to specific city typologies, politics, economics, cultural and legal circumstances etc.

Conclusion

In conclusion, Living Lab flavoured mechanisms like Organicity offer a wealth of opportunities for researchers in understanding the co creation journey of new technological solutions including; the methodologies employed, the challenges experienced and how they are overcome. In the context of Thriving Smart Cities, engaging in real world experimentation sensitises researchers to the rich context of cities that includes non-human actors, whilst co-creation enables citizens to have input as initiators of experiments and co-designers of solutions. Already, case studying Organicity has given us insight into how cities can better cater for 'Living Lab' mechanisms, the value of these mechanisms, 'multi-city' experimentation and scalability challenges uncovered by doing multi-city experimentation. As the second round of experimenter funding in Organicity comes to an end, we will shortly be analysing the journey of all 40 experimenters throughout the lifecycle of the project, and offering learnings into methodologies which suit particular types of solution development, as well as the specific challenges researchers should be mindful according to each. Finally, we believe that examples like 'Wayfindr' in particular serve to

showcase new methodological approaches to co creation not previously reported in the academic literature, as well as the value and challenges of 'co creation', 'real world' and in particular 'multi-city' experimentation bring.

Background

Shane is an SFI (Science Foundation Ireland) and Intel funded Post-Doctoral Researcher for LERO (The Irish Software Research Institute) at National University of Ireland Maynooth. His current research examines the development and adoption of disruptive digital innovations with societal benefit. Shane focuses on approaches to urban data/IoT and Autonomous Vehicle software development and related sustainable business models. Furthermore, he is Collaborator on a SFI Science Policy project examining best practice in peer review of grant funding (award: '17/SPR/5319'). As Collaborator, he is exploring peer review of industry-academic collaborations. Shane earned a PhD in Information Science at the School of Information and Community Studies at University College Dublin (UCD). The PhD in the domain of 'Human Information Behaviour' and 'Social Informatics' tested and explored the role of ICT on Social Aspects to Everyday life Information Seeking (ELIS) Behaviour. The thesis developed the concept and measure of Information Social Capital, drawing on the theory of Social Capital by Professor Nan Lin, who also acted as external examiner. Finally, he is consultant for the European Commission & European Council Partnership's 'Connecting the Dots' Symposium on 'Youth, Digitisation & Social Inclusion'.

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