The Internet of Things

The Language and Practice of Early IoT Adopters 2011-2013

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ABSTRACT

This thesis examines the discourse and practice surrounding the technological development of the Internet of Things, and its expansion at the start of the second decade of the 21st century. The initial motivation for the Internet of Things was a fusion of the physical and digital worlds, enabled by pervasive network connectivity: "anything, anytime, anywhere". Grounded in a rhetoric of a connected world, future sustainability, and improvements brought by the deployment of innovative techno-socio-economic-environmental systems, claims were made that the IoT would not only deliver solutions to humanity's ever-growing needs, but would also lead to a shift in the very principles governing such systems. This thesis argues for the need to readdress the dominant IoT discourse, not only by an analysis of discourse, but also by an analysis of the practices that fostered the development of this phenomenon.

The study at the centre of this thesis is focused on a community of open source developers, artists, architects and computer enthusiasts who were curious about the possibilities opened up by this next stage of technological development, and who went on to test and re-imagine the use and deployment of the IoT. This ethnographic study follows the development of the first IoT platform, the creation of a community-led air quality network, and the emergence of the Open IoT framework. Through an analysis of practice, and an examination of its conceptual content and organisation in language, this thesis reveals how the space of the IoT was imagined, experienced and lived in. The thesis argues that investigations led by these early adopters and the re-imagining of what Lefebvre called the "dominant space" pioneered the IoT discussion and its development during 2011-2013 in London, Europe, and America. Connecting with the social theorists in the fields of critical theory, phenomenology and social geography, this thesis provides a new viewpoint on technological development, and in consequence, it expands the currently rather technological discourse of the IoT.

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In memory of Armin

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INTRODUCTION

As a society, over the last hundred years, we have experienced enormous changes. From an industrial society of the 19th century we have become a networked information society of the 21st century. At the start of the second decade, the dawn of the Internet of Things (IoT) promised the further integration of the physical and digital worlds; it also predicted a deeper shift in the spheres of economics, social life and environmental sustainability. While this thesis will explore several meanings, technological capabilities and the history of the Internet of Things framework, at this point it would be sufficient to say that in the broadest sense, the IoT encompasses a vision where 'anything, anywhere and at any time' is connected to the Internet. Simple sensor devices, home appliances, cars, everyday objects, wearables and the environment, 'things' will gather and share information in an automated system. According to Cisco, the number of connected objects on the Internet had already exceeded the number of humans in 2008, and by 2020 there will be 50 billion devices connected to the Net (Evans, 2011).

Today (2019) the term Internet of Things has become more pervasive as more and more internet-connected devices enter the market space. From self-driving cars and connected home appliances managed by Amazon's Alexa to the emergence of industrial IoT, energy IoT and smart IoT, the Internet of Things seems to be everywhere, and business is expanding. Early in 2018, *Business Insider* predicted that business spending on IoT solutions would be about $6 trillion by 2021[1]. The 2019 predictions see the IoT penetrating deeper into the spheres of manufacturing,

1 See https://www.forbes.com/sites/danielnewman/2017/12/19/the-top-8-iot-trends-for-2018/#1f2fa24067f7

healthcare and the building industry. Yet, as analysts have noticed: “Despite the huge gains in connectivity, the truth is” the growth and implementation of the IoT is “full of fits and spasms, and everything that goes along with them - ‘fragmentation frustration’, potential data breaches, and security issues galore” (Newman, 2018).

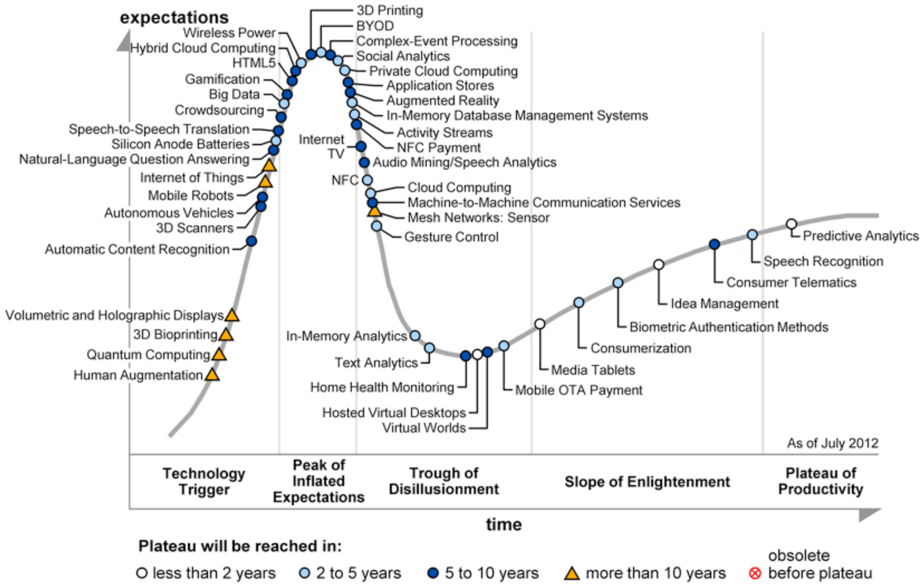
As this thesis will explore, such predicaments have followed the IoT development from the time of its conception. To confirm this suggestion, this research will look back at the events that took place almost a decade ago, at the time when the first IoT platform was developed and the IoT framework emerged into public view. At that time (2010-2013), there were mostly connected phones, computer terminals, and other such machines of the Internet era, and there were only a few commercial products that could be categorised as part of the IoT[2]. The IoT was mostly explored through its visionary potential and technical prototyping. However, the visions and narratives developed back then still resonate today. For some, the IoT holds the promise of significant progress in addressing global and societal challenges (Sundmaeker, 2010; Foth et al., 2011; Yeomans, 2012), while others see its potential in improving daily lives on an individual level (Weiss and Craiger, 2002; Combetto, 2006; Fleisch, 2010). A few years ago, some went as far as to envisage the IoT as the 4th industrial revolution that would bring about a total paradigm shift in all aspects of our lives (Rifkin, 2014). Above all, the turn of the decade was the time when investments started to flow, and the IoT was seen as a highly promising economic sector for sustainability, growth, innovation and employment (Estrin, 2004; Fleisch, 2010). In 2012 Gartner, one of the leading information technology research and advisory companies[3], named the development of the Internet of Things (IoT) among the top 10 technological trends in IT that would be of strategic importance for the ensuing decade. Gartner's hype cycles are concerned with the cycles of development of a particular technology, and its impact on business developments[4]. As can be observed in Gartner’s diagram (See Fig.1), the Internet of Things in 2012 was placed

2 One such example was Nabaztag (2005-2009), a Wifi-enabled, rabbit shaped device that could download weather forecasts, stream music and read its owner's email. A long period of technical difficulties led to the bankruptcy in 2009 of the French company developing Nabaztag.

3 See also IoT Business News 2012: https://iotbusinessnews.com/2012/11/20/29763-internet-of-things-in-the-top-10-technology-trends-for-2013-according-to-icreon-tech/

4 Economist Christopher Freeman from the Science and Technology Policy Research Unit (SPRU) at University of Sussex developed the theory of innovation in industrial societies (Freeman, 1974). The subsequent concept of the "techno-economic paradigm" was later introduced by Carlota Perez (1983). Building on Schumpeter's ideas, Perez (2002) further divided the 50 years-long wave cycle in business. (Initially developed by Nikolai Kondratiev).

at the point of “Technology Trigger” - the first phase of a business cycle or a breakthrough stage.



1. Gartner’s Hype Cycle: Predictions for 2013

The 'trigger stage', or what Carlota Perez named *the first quarter*, is when innovation and entrepreneurial activities are taking place. It is usually a time and space when the so-called early adopters - inventors, entrepreneurs, risk-taking financiers and other forward-looking people - are involved in building and testing new ideas, products and applications (Perez, 2002). Medosch (2015) suggested that the list should also include “artists, activists, and independent technologists, whose contributions are often overlooked by mainstream analysts. Once they have been able to show the feasibility of an innovation, others jump on the bandwagon and an investment frenzy starts” (Medosch, 2015, para 4). As Perez points out, it is this space and time of innovation that requires closer study and analysis. As she suggests: “That space is essentially dynamic and, in it, the basic concept is that of a trajectory or paradigm, which represents the rhythm and the direction of change in a given technology” (Perez, 2009:4).

From the start of this research, the boundless nature of the IoT phenomenon presented a challenge in terms of issue choice. As a practitioner, I was excited to explore the materiality of technological abundance proposed by the ubiquity of network computation and its influences on human perception. In my own practice, around 2007-2008, I was lucky to have collaborated with the artists Alexei Blinov and Armin Medosch on the development of Hive Swarm and Hidden Histories. These two media art projects, which explored the embedded computing concept by planting small wirelessly-connected microcontroller boards into city space, were creating new public interfaces, where histories of place could be heard in their immediate proximity. These playful experiments and the impact they had on passers-by taught me a lot about the power of such technologies, and the ways they could shape the perceptions about, for example, a particular place. What before was a simple lamp post became a place with a rich history, infused with memory and emotion.

Of equal interest was the contemporary practice in which the visions and actions of small groups of individual collaborators could create a situation, set new beginnings and influence not only the discourse but also the direction of technological developments. The emergence of the IoT coincided with the upheavals of the Arab Spring (2010) and Occupy Wall Street (2011), which ignited a number of grassroots initiatives aimed at rallying around the common and shared domains. From groups concerned with self-organisation or grassroots movements to those occupied with environmental struggles, empowered by new technologies, many believed that a different world was possible. Similarly, there were those who believed in creating tools that could empower, motivate and facilitate the collective voice, collaborative culture and, subsequently, influence the change to come. How can such practices be conducted in the material-economic conditions of their time? What approaches and strategies are there to consider? What technological solutions are embraced? And what effect could these grassroots aspirations have on the future of the IoT?

As noted already, most of the discourse surrounding the IoT phenomenon at that time was driven by its technological frameworks, and developed in a context of large computer science and business research centres[5]. By 'discourse' in this thesis I will be broadly referring to an interrelated set of texts and practises that bring an object, in this case the IoT, into existence (Foucault, 1969; Parker, 1992; Phillips and Hardy, 2002). There were also debates in the boardrooms of policy-makers and among

5 It is worth noting that it is only during the last decade that there has been a rise in research conducted in a context of social science on the implications of the IoT, in terms of privacy, ethics and its data-driven paradigm.

governments in the EU, USA, Japan and China[6]. In the EU, for example, the descriptions of IoT visions often included a sense of urgency that was highlighted by questions about the directions this new paradigm should take, or how European values could be implemented. The language used in these contexts to describe the future visions of a connected world often reflected a certain techno-determinism that promoted the autonomy of modern science and technology, and its close relationship to economic growth. This view implied that the advance of modern technology consists of the process whereby artefacts are continually being modified in order to enhance or extend our mastery of the world. Schroeder described this techno-determinist view particularly well in a context of large technological systems: “the emergence of big science and large technological systems not only shapes the physical or natural world but it also transforms society independently of social forces” (Schroeder, 2007:10). This discourse, generated in boardrooms and in the belly of what Schroeder termed the 'juggernauts'[7] (Schroeder, 2007:138), I will broadly, for now, call here the dominant discourse of the IoT.

The desire to move away from this dominant discourse, to explore alternative visions and the two personal trajectories identified above, led me to consider the Pachube project, initiated by the London-based architect Usman Haque, and its community of open source contributors as a source of study for this thesis. There were two reasons for this consideration. First, Pachube became known as the first IoT platform[8] devoted solely to the coming era of connected devices. Secondly, it was a successful start-up story that bridged the boundaries between the creative media and art practice with that of new business models of digital capitalism. While the former offered a hands-on practical experience with the technical infrastructures of the IoT, the latter

6 The concept of Internet of Things was adopted by the EU in the Commission Communication on RFID (2007), and EU research cluster on the IoT was set up in 2008. In the USA, the first discussion on the IoT was in a report named "Disruptive Civil Technologies” published by the National Intelligence Council in 2008. In 2009, Chinese Premier Wen Jiabao made a speech calling for the rapid development of the Internet of Things, and called it the “Wisdom of the Earth”. In 2008, Japan set up the Priority Program 2008 to “realise the ubiquitous and universal network society where everyone can enjoy the benefits of IT.” (See Santucci, 2010)

7 In describing the large technological systems, Schroeder characterised them as: they “always bring together technological artefacts and social institutions. Second, these systems have an inbuilt movement or trajectory. Third, this trajectory means that systems become 'locked in'. Fourth, the concept is functionalist, which entails that it must be embedded in an environment that has a 'need' for this increasing intertwining and scale and scope” (2007:45).

8 Pachube was ‘one of the first available cloud-based services for managing sensor data, that provides a light application programming interface (API) for sending data directly from sensors, and whose web environment allows the visualisation of data in graphs’ (Doukas, 2012).

presented me with an opportunity to witness how a community of like-minded people tried to shape not only the technological but also the social framework of this emerging phenomenon.

Pachube emerged (2008) out of a project called Extended Environments Markup Language (EnvironmentXML), initiated by Haque in 2006[9]. EnvironmentXML was built as a system to help him monitor the status of his interactive art installations in far corners of the world. One could argue that at the beginning it was a technical solution to a necessity, i.e. to monitor his connected devices. It could also be seen as a conceptual artwork, an example of information architecture or as a conceptual system design[10]. As a practitioner in the field of interaction design and architecture, Haque had engaged with questions of spatial practice, both on a theoretical and practical level. In his original proposal for the EnvironmentXML (2006), Haque wrote:

> *A big inspiration for the project is Stafford Beer's Cybersyn project, developed in Chile 1970-73[11] to link up factories throughout the country so that they might report (via telex machine) and respond to real time conditions. The purpose of the project was to apply second-order cybernetic principles to the regulation of the factory systems and environments. EnvironmentXML could be a sort of peer-to-peer version, enabling the creation of complex interactive art and architecture interfaces that respond not only to local but also to global conditions.*[12]

Like Beer, Haque was interested in the development of a bottom-up version of a distributed computer system that supported peer-to-peer creations and facilitated feedback and information flows, as opposed to systems of surveillance that disciplined and dominated. Moreover, as an architect, Haque was interested in connected and conversant environments that were dynamic and responsive. Haque often cited his other influences - the work of another cybernation expert Gordon Pask

9 See more details on EnvironmentXML here: http://www.eeml.org/

10 In June 2006, Haque wrote a proposal titled EnvironmentXML for a residency at Eyebeam, a not-for-profit art and technology centre in New York. A quote from the e-mail conversation with Haque read: “and it was an unsuccessful application. For some reason I was nominated for a "production commission" which, as I remember, involved residency, but the point was that they had a technical team to help realise things; so I was applying to take what I'd already built in mysql/php (which, from memory, had about 30 or 40 other users at the time) and scale it up. In retrospect, I think it's lucky that they turned me down”.

11 http://en.wikipedia.org/wiki/Cybersyn

12 From personal collection of Usman Haque. Sent by e-mail on 23/11/2012

and his conversation theory, and the Dutch artist and situationist Constant Nieuwenhuys and his proposal for the New Babylon (developed from 1956), a visionary society with its globally connected architecture, built, configured and reconfigured by its inhabitants.

In July 2011, this rather small artist-led platform was acquired by the Boston-based cloud-service provider LogMeIn[13]. Subsequently, the new web interface was launched as its backend infrastructures were gradually merged with those of LogMeIn[14]. While the initial considerations, rooted in interactive, social and architectural approaches, might have lost their importance in this later context, its peer-to-peer disposition enticed Pachube users for a few more years. The infrastructural alterations on access, data exchange and ownership gradually shifted away from community-oriented support to that of an established business model. However, the newly-acquired resources not only allowed Pachube to continue scaling, but also opened up an opportunity to engage community organisers and support community-oriented activities for a little while longer.

From its start, the Pachube community was formed by a small but highly energised community of early adopters, hardware hackers and DIY enthusiasts. Initially, the largest group were enthusiasts engaging with home energy monitoring systems, and one of the earliest clients was the energy monitoring device manufacturer Current Cost[15]. In March 2011, after the devastation caused by the tsunami in Japan and the meltdown at the Fukushima nuclear power plant, Pachube became the network centre to many concerned citizens. In response to poor information available from government sources, people networked their private Geiger counters and particle detectors in order to measure the emission of nuclear radiation. In less than 24 hours, interactive designer Haiyan Zhang created the Geiger map that pulled all the real-time data from Pachube, uploaded by hundreds of citizens in Japan, Europe and the Americas, and visualised the radiation movement in real time.

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13 Pachube was bought by LogMeIn for $15m in cash. Many, also supported by the press, wondered why it was sold so early. One report suggested it was because of its unsustainable scaling model http://readwrite.com/2011/07/20/pachube_acquired/. See more reports here: http://realbusiness.co.uk/any-other-business/2011/07/21/logmein-buys-uk-start-up-pachube/

14 https://secure.logmein.com/

15 For more details on early clients and advisors see Noble (2009).

Inspired by such public participation, later that year, Pachube sponsored a community-led research and development project, the Air Quality Egg (AQE), that set out to develop a low cost, broadly-available networked air quality monitoring device. Through its established network of communities in cities like New York, London, Madrid, Amsterdam, Barcelona, Munich and their regular IoT meetups, work began on collaborative hardware and the subsequent AQE network development. However, after the relaunch of the new company's identity in 2012, friction between the community and the company started to emerge. That, for example, led the New York-based group to dissociate from Pachube and its IoT meetups, and reorganise themselves in a new, independent formation centred around sensemake.rs, a site for a community of designers and technologists working on urban social and environmental problems[16].

As I immersed myself in observing these developments and passions of the early advocates of the IoT (2011-2013), it became apparent that nearly a decade of Web 2.0, platform and digital business structures had changed the way we navigate online and offline spaces in order to organise, re-organise and rally around issues of social importance. Likewise, what initially were grass-roots methods, of DIY workshops and community-led events, bottom-up approaches such as self-organisation, participation and community engagement had become instruments of corporate commodification. It became evident how, by understanding these circumstances and the limited time window of the 'trigger stage' developments, these IoT pioneers rushed to create something that would set a precedent not only for an open and human-centric practice, but could also influence the larger development of the IoT and, in particular, the debate around the Open Internet of Things.

As Perez pointed out, those formative years were not only dynamic, but it was also a time when the direction of change for the future trajectory was negotiated. In the midst of all the players, there were many established researchers, innovators, individuals, start-ups and, as Medosch pointed out, activists and artists. They all brought their visions and values to affect that trajectory and the rhythm of the developments that would define the years to come. It is not, however, often that those of on the edges, and the convictions they bring to their conceptions, survive the

16 Usman Haque left Xively in 2014.

frenzy of the investment stage, or make a lasting impact on emerging development. The impact that could shift, if only slightly, the discourse, the trajectory, just an inch away from the greed, from the only-for-profit oppression, from the inertia of the juggernauts. To move from that inertia and to modernise and to improve, without asking: Why are we doing it? Or: Is there another way to do it? We have seen it in the past (see Barbrook, 1995; Medosch 2015), with previous technological innovations such as the radio, TV, the Internet – all these technologies had the potency to empower society and communities in two-way and then network communication, and not just become uni-directional propaganda carriers, or a means of surveillance and control. Yet, while the first two have succumbed to the dominant forces of capitalism, the Internet, with its open and ethical values (developed in a framework of public universities) at its core, still fights for its future[17].

Likewise, the story of the IoT is still unfolding. As it will be argued in this thesis, the IoT context offers us a chance to readdress the local, proximal and physical, to combine and bring back the balance between global and local visions, to put the technologies of the IoT to work for issues that matter to all of us. It could give the planet a voice. It could make us more aware of the impact we have on the planet, on other creatures, on our resources. We must improve the conditions of today, and that means addressing the environment and, in some ways, the failings of the current paradigm. This, however, is not a technological matter but rather a social and political one. As cultural theorist Armin Medosch argued, a discussion focusing only on techno-economic questions suffers from an inherent weakness by holding on to a depoliticised view of history: “History is not only defined by economics and technology, but also by politics, which implies raising the fundamental question of how we want to live, as individuals and as social groups or classes.” (Medosch 2015, para 6).

It could be argued that it might be too late as the IoT is already on a set path. However, those 'fits and spasms' the IoT implementation encounter (I will address the challenges later in Chapter 2) offer some hope that at some point in the near future the need to readdress the current path might arise. As has been noted, people

17 See: https://www.theguardian.com/commentisfree/2018/mar/12/tim-berners-lee-web-weapon-regulation-open-letter

are losing their trust in technology companies (Confino, 2015; Forrest, 2017; Wald, 2018). Currently implemented IoT systems deepen our sense for self-surveillance (Penney, 2016) and arouse feelings of unease (Fingas, 2018; Palladino, 2018). The rise of hacker groups such as The Dark Overlord, who care little about the social good and desire only economic benefits, further undermines the current system, and not just in terms of security. Together these forces, combined with those calling for more ethical, responsible, transparent and open practices in the field of technological developments, might necessitate some shifts in trajectory, or the legislative frameworks governing the current practices.

On the other hand, any technological development is also an asymmetric struggle that is not defined but shaped by all those involved. That is why there is a need to address these practices on the edges, to acquire the knowledge and understanding of the diversity that exists, the motivation and passion for addressing the issues that are common to all of us, as a global society of people in a real and physical space/place. We should never underestimate their contribution to the emergence of one or other discourse, or to the struggles that persist. While the centrality of the technological development can still be observed on all levels, be it in EU boardrooms or at the meetings of citizen science projects, alternatives encompass the reasons and motivations for these developments, and also approaches that could be taken to achieve given challenges, or methods used to integrate the physical with the digital in more considered ways. The calls for development of more bottom-up, hands-on, decentralised and human-centred approaches are made across fields. For example, the increasingly popular discourse surrounding debates on smart cities has given prominence to the issues related to citizen engagement with IoT technologies (Vanolo, 2014; Mullenger, 2017). The rise of Fab Labs and Bricolabs offer more hands-on approaches, and advocate the need for empirical learning in the field of technologies that would empower people to make informed decisions about the use or application of one or other technology. As this thesis will explore, there always existed alternative views to the dominant one.

Set in this broader context, and acknowledging the growing knowledge generated across IoT discourses, this thesis will focus on the ideas, concepts and social aspects of practice in the formative years of the IoT. By focusing on one group of people who did their best to influence the direction and to shift the debate on the developments of the Internet of Things, it will investigate the complexity of both the practice of implementation of IoT visions and the perceptions that defined it. By focusing on the ways they went about making their IoT visions into reality, the thesis aims to address the corporeality of everyday practice and the spaces it navigates. The study attends to questions such as: What do the developers in this community think they are doing? Why are they doing it? How are they doing it? In the process, the thesis will explore what was actually done, how their perceptions and practice related to the dominant mode of production, and what their practice and language can tell us about the IoT. Likewise, this thesis aims to explore the ways meanings, decisions and understandings were reached in communal deliberation, and how the perception of the emerging IoT space was shaped by the language and social conditions of the time these developments were taking place.

1.1. Research Questions

This thesis investigates the emerging phenomenon of the Internet of Things, its historical context, and how perceptions of it were shaped at its 'trigger stage' of development. The thesis accounts for and discusses the practices and perceptions of one group of early IoT adopters as they went about developing an early example of an IoT device, and participated in shaping the surrounding discourse. In doing so, it aims to address the following research questions:

- How can the understanding of the IoT phenomenon be extended beyond the dominant discourse?
- What does the perceptions and practices of early adopters tell us about the emergent IoT phenomenon?
- How and by what means is the IoT space constructed and negotiated?
- What does the practice of this community tell us about changing relations in production processes, resources and approaches?
- Can the analysis of collective practice and discourse help us to illuminate issues the IoT phenomenon has brought to the foreground and thus help us to understand the changes it has brought to the social world?

1.2. Chapter Summary

The thesis is organised in two parts. Part 1 emphasises the theoretical perspectives that informed this research, and Part 2 focuses on the empirical study, and is motivated by the theoretical contributions explored in Part 1. **Chapter 2** explores and addresses the theoretical concepts relevant to this thesis. The first part of the chapter engages with the specific IoT discourse at its trigger stage development. IoT visions, research paradigms, and challenges will be addressed through an analysis of relevant literature, white papers and consultation reports. The second part of the chapter will consider how the IoT framework could be narrated from two perspectives - the 'thing' and the network. In order to locate my study in the history of the proliferation of the IoT phenomenon, this section will uncover the historical context and, in particular, will search for the contributions made by artists, writers and social geographers or, in other words, the endeavours of thinkers outside traditional computer science and industry frameworks. To contextualise such practices, and the empirical research at the centre of this thesis, this chapter will engage with the question of how the narrow technological framework in which the most dominant IoT discourse is situated could be extended into a more social one. The approach suggested here will consider the lens of spatial and social analysis and, in particular, how the thinking, in terms of spatial production and meaning of social action, can help to unveil social processes at work.

Chapter 3 will address the chosen case study in more detail, as well as the adapted methodology. As the thesis aims to disclose both the visions and workings of this one particular group and the intricacies of the larger IoT framework, the study's intrinsic and instrumental nature will be highlighted. The framing of a community, multi ethnographic method approach and the methods of data collection and analysis will be discussed. The methods embraced aim to address the centrality of participant perspectives and the contributions the research could make to an intersubjective understanding of the embodied, experiential meanings of the IoT phenomenon as it was concretely lived and experienced by this group of open source developers. The thesis adopts the view that phenomenology and linguistic anthropology are one way of gaining access to another person’s perceptions and internal perspectives, through description and the examination of conceptual content and its organisation in language. It also recognises that language, perceptions and experiences are always relational to the social space and the practice of their producers, whose intent, as it will be uncovered, was to expand the narrow technological discourse of the IoT into a more public and open domain.

Chapter 4 turns to the study of the community of practice by uncovering the participants' own perceptions of its nature, formation and its relationship to a larger IoT framework. It reports the analysis of qualitative data obtained through interviews with a number of key community members to uncover the subjective meanings and common concerns that hold this community together. This part of the study will explore the perceptions of the community participants, and the things that mattered and propelled them. Chapter 4 is divided into subsections to highlight different aspects that have motivated their work, their involvement with the emerging IoT framework and the collaborative culture they advocated. The chapter will explore how their motivations were not only intrinsically positive but also became the productive force, both for community cohesion and the expansion of the IoT space itself. The study will probe the linguistic markers and ideological frameworks applied to uncover the inner workings of this community, the intricate and complex subjectivities of participants themselves, and the understanding of the importance the speakers assign to the IoT-specific domain.

Chapter 5 investigates the conditions of everyday practice, and how this community of early IoT adopters went about organising, designing and producing the discourse and practical instance of an early example of an air quality measuring device, and the subsequent development of a community-led air quality network. The chapter will explore the complexities of air quality, the historical approaches to its measurement, and how engagement with this phenomenon not only created a framework for public engagement, but also how, in the process, it transformed the community of practice into a network of citizen scientists. The complexities involved in the measurement processes will be foregrounded as it is here where not only the key everyday challenges lay for IoT implementation, but also where the logical space of the being and the geometrical space of the physicist is negotiated. The chapter also explores the emergence of online platforms, such as Pachube, Meetups and Kickstarter, and the role they played in enabling the spread of the IoT discourse, and how they supported the development and production processes of the AQE project. The chapter will examine questions about how this new spatial configuration, extended b y the social platforms, supported or limited public deliberation, knowledge production and dissemination. Likewise, the legacy of the AQE project and contributions made by this group's collaborative action will be discussed.

Chapter 6 immerses itself in data gathered during the final event organised by this community – the Open IoT Assembly, a two-day event that took place in June 2012 in London and which established the base for the emergence of the Open IoT framework. The event gathered the key IoT players of the time, both from the private and public sectors, to deliberate on the meaning of the Open IoT framework, and to develop the Open IoT Bill of Rights proposal. Through the analyses of ethnographic data, transcripts of discussions and negotiation processes, the chapter explores the emergence of the discourse at the heart of the IoT paradigm – that of data, as well as the changing perceptions and power relations it brings about. Through the analysis of the pervasiveness of the data concept and the uses of the word data in language, the chapter seeks to uncover the culturally specific context and the webs of meanings speakers attribute to it, and thus its impact on the social world.

Chapter 7 discusses the key findings of this study, and its role in understanding both the practice of these developers and the wider context of the IoT. It argues for the relevance of such practices and their role in developing more human-centric and participatory approaches to IoT development. In addition, it addresses the methodological choices in addressing both the observable and perceptual realms, and conclusions that could be drawn from the distance of time. The chapter also highlights the study's contribution to the history of the Open IoT framework and the emergence of the IoT data discourse.

The final chapter, **Chapter 8,** draws up the conclusions of this thesis, and highlight the main contributions made by this research. The chapter also will address the frameworks for future work, and the areas for further research.

PART I

THEORETICAL FRAMEWORK

2

THE INTERNET OF THINGS: HISTORY AND CONTEXT

2.1. Overview of IoT Technologies and the Evolution of IoT Discourse

This section will examine miscellaneous literature, research papers and related media articles tracing the proliferation of computing technologies and the discursive practices that have given rise to the IoT phenomenon. The corpora of knowledge created in publications over the past few decades provide insights into the history of IoT discourse, different frameworks for development of IoT-related technologies, and the complexity of technological and social issues involved.

Visions of technology are often contemporaneous. While the current vision of the Internet of Things is largely founded on the idea of a network of connected objects, its pedigree is found in the concept of distributed computing or ubiquitous computing. This was developed in 1988 by Mark Weiser, a chief scientist at Xerox PARC. Building on his research on human-computer interaction and influenced by Xerox PARC's work on networking technologies, Weiser advocated the concept of ubiquitous computing[18], which he saw as the third wave of expansion the first being the mainframes of the 1960s and '70s; the second being - personal computing of the '80s and '90s. In his view, ubiquitous computers embedded in the appliances around us had intelligent interfaces and 'anytime, anywhere' data communications. He promoted this third wave as a world in which computers would “vanish into the background”, weaving “themselves into the fabrics of everyday life until they are indistinguishable from it” (Weiser, 1991:19). This, he stated “will make using a computer as refreshing as taking a walk in the woods.” (Weiser, 1991:25)

18 UbiComp evolved from the mobi-Comp and incorporates four distinct research thrusts: smart spaces (e.g. meeting rooms, cars and hospitals), invisibility, localized scalability and uneven conditioning.

Without doubt, Weiser's work and vision are at the core of technological developments of IoT-related systems. However, the current, dominant phrase ‘Internet of Things’ is largely accredited to Kevin Ashton[19], co-founder and former head of Auto-ID Center at the Massachusetts Institute of Technology (MIT), which at the time was a leading designer of Electronic Product Code[20] (EPC) and the propagator of radio-frequency identification (RFID) technology[21]. Ashton used the ‘Internet of Things’ as a title for his presentation delivered to Procter & Gamble (P&G) in 1999 (Ashton, 2009). While selling his vision of tagged things to corporate merchants, Ashton argued essentially “we're physical, and so is our environment. Our economy, society and survival aren't based on ideas or information - they're based on things” (Ashton, 2009:1). Through the identification of everyday objects and products, conceivable by the use of RFID[22] and their management, he envisaged “the system that would use the data gathered without any help from us humans” (Ashton, 2009:1).

The rapid developments in automation and sensing technologies, wireless communications, and distributed data processing over past decades have narrowed the gap between Weiser’s vision of ubiquitous computing and connected ‘things’ promoted by the Internet of Things paradigm. I argue, however, that it is Ashton's visions of thing identification, management, automation and data gathering in corporate frameworks, that has prevailed in the dominant IoT discourse. This is best illustrated by the language used to describe the promises and visions of IoT, already highlighted in the introduction of this thesis. Examining a vast number of IoT-related research papers, often produced in a relation to a prototyping stage of one or other technology, it could be observed that the language used in describing their imagined future benefits frequently repeats same few ideas. The benefits of IoT are often associated with questions of sustainability and better resource management, energy and financial savings (Estrin, 2004), greater productivity in business, and the development of new industries (Fleisch, 2010). On a more personal level, IoT

19 See references in Wikipedia here: http://en.wikipedia.org/wiki/Internet_of_Things

20 Electronic Product Code (EPC) Network was launched in 2003, with its three new services that allow organisations to manage EPC data using the Internet: ONS Registry, EPC Service Registry and EPC Information Services.

21 The first mention of IoT in a published context, was in 2001, in a white paper on proposed Electronic Product Code (EPC) presented by David Brock from Auto-ID Centre (Brock, 2001:5).

22 Technology first was developed by Russian Lev Termen, inventor of the Theremin, a musical instrument with a proximity sensor.

systems and devices are seen as something that could also make life much safer (Mattern et al., 2004), while another, less discussed - but vital - aspect of IoT adaptation in everyday life, suggests its ability to change human behaviour (Fleisch, 2010).

In 2008, the European Technology Platform on Smart System Integration (EPoSS)[23] published their *Internet of Things in 2020* report (EpoSS, 2008) that elaborated upon a future vision of IoT. The particular focus was governance, standardisation and interoperability - absolute necessities if things are to communicate with each other – or, in Ashton's words: “data gathered without any help from us humans” (Ashton, 2009:1). In other definitions of IoT - published by Strategic Research Agenda of the Cluster of European Research Projects on the Internet of Things (CERP-IoT, 2009) - Weiser's vision was re-articulated in terms of a promise of anytime, anywhere and anything connectivity, where humans, objects, data and environments all interact with each other in the same space and time. However, it was Ashton's application to such systems in business frameworks that found its way into the re-articulated definition. It was formulated thus: “The ‘things’ are expected to become active participants in business, information and social processes where they are enabled to interact and communicate among themselves and with the environment by exchanging data and information ‘sensed’ about the environment, while reacting autonomously to the ‘real/physical world’” (CERP-IoT, 2009:4).

Though RFID and ubicom frameworks are here to stay, if we turn to research conducted within a more technological frameworks, other technologies such as small sensor devices, mobile networks and wearables have broadened today’s research area. Recently, there have been a number of different frameworks in which IoT - related technologies have been explored. This not only illustrates the heterogeneity and complexity of the phenomena, but also how IoT discourse has expanded across a number of different research fields. Some of examples are: pervasive computing (Spohrer and Stein, 2000; Burkhardt, 2001; Hansmann, 2003), which often describes the same idea to ubiquitous computing i.e. computers everywhere; sentient

23 EPoSS brings together European private and public stakeholders to create a basis for structuring initiatives, for co-ordinating and bundling efforts and for establishing sustainable structures of a European Research Area on Smart Systems Integration.

computing[24] with its attention to sensor adaptation (Hopper, 1999; Schmidt, 2003); attentive environment, with its focus on service networks (Spohrer and Stein, 2000; Maglio et al., 2001); ambient intelligence (Aarts et al., 2002; Punie et al., 2006; Ramos et al., 2008; Dohr et al., 2010; Wright et al., 2010); and embedded computing and machine-to-machine learning (M2M). More recently, some have argued that the Internet of Things is not synonymous with any of the above, but rather IoT combines all of these technologies in one new framework (Haller, 2010; López et al., 2011; Uckelmann et al., 2011).

The IoT appropriates not only technologies developed on a device level, but it also extends the current network structure through assimilating other layers of device-specific network architectures such as EPC, wireless sensor networks and mobile nets. As Reinhardt (2004) points out: "It's that enticing mix of local and remote communications, all seamlessly linked together, that's inspiring a rush to construct the new Internet of Things" (Reinhardt, 2004, para 5). Like the Internet, IoT utilises technical protocols such as DNS, TCP, and IP and the physical network infrastructures, such as cables, Wi-Fi and gateways that match the IoT requirements, among them low energy consumption, low cost, and mobility (Sarma, 2004; Fleisch, 2010). Others have pointed out that network requirements for the IoT cannot be met by the networks and solutions we have today (Zouganeli and Svinnset, 2009). This has led for numerous calls to rethink and develop a new, IoT- specific network architecture (Pujolle, 2006; Grønbæk, 2008; Ning, 2011). Pujolle (2006) pointed out that the main TCP/IP drawback for integration of wireless sensor, RFID or VoIP terminals is their energy consumption. Other limits of the TCP/IP, such as reliability, buffering and security, are also seen as a failing point, and fosters the research in this area. However, the TCP/IP protocols are based on open system architecture and thus a large number of parameters can be optimised; likewise, the introduction of IPv6 is seen as a positive shift towards overcoming some of the IPv4 limitations[25] (Atzori et al, 2010). As it stands (2017), there is a working group in place at the IEEE standards association who have developed a Draft Standard for IoT Architectural Framework[26].

24 The term 'sentient computing' was coined at the ORL research labs in Cambridge (later the AT&T Labs). They define the term as follows: "Sentient Computing: Using sensors and resource status data to maintain a model of the world which is shared between users and applications." (AT&T 2001)

25 See also: Ward (2012).

26 Some scholars have argued that the diversity and complexity of issues involved mean that "in all

IoT data-related issues - such as scale or nature - in IoT specific literature, have only recently been discussed (Wu et al., 2014). Combining the data of mobile, identification and sensor networks is needed to increase the contextual sense of a particular object. For it to be meaningful, for both devices and humans, it requires a large, open and interconnected network of data so that meaning is made in its circulation. Likewise, the physical surroundings must be described in the ways the data is given rich semantics that can further appropriate semantic web structures and middleware. This requires interoperability of currently fragmented systems. To counter the growing fragmentation of current IoT developments the World Wide Web Consortium (W3C) recently launched their Web of Things Working Group (2016) to develop initial standards for what they call the Web of Things[27].

Furthermore, as this research field expands there are a growing number of research papers that tackles the challenges of this emerging domain. Some have addressed the new research framework vocabulary and pointed to the folly of such an all encompassing vision (Atzori, 2010; Sachs et al., 2010; Chui, 2010; Sundmaeker, 2010; Jain, 2011). On the system level, there are challenges of massive scaling, distributed architecture and dependencies involved in creation and management of trillions of connected objects (San Miguel et al., 2012; Gubbi et al., 2013; Stankovic, 2014; Xu et al., 2014). On a device level, there are issues such as sensor device automation, implementation of low energy consumption, application context aware and context sharing methods, as well as the overall integration of security and privacy protection requirements (Gubbi et al., 2013; Perera et al., 2014). On a network level, there are similar challenges, such as interconnectivity of different network systems, building the resilience of networks and providing the network-wide security for dynamic network integration (Havlin et al., 2012). As one recent (2016) IoT network hack[28] highlighted, there are a great number of security issues of IoT (Ning et al., 2013; Ray and Raychowdhury, 2016).

Scholars have also pointed out that IoT data-related issues lead to a variety of non-technical challenges concerning social, legal and ethical issues - such as

likelihood, there never will be one" unified IoT standard (Fleisch, 2010).

27 See more on: https://www.w3.org/WoT/WG/

28 The attack on global internet access, blocked some of the world's most popular websites such as Twitter, PayPal and Spotify and was believed to have been unleashed by hackers using common connected devices such as webcams and digital recorders. (See: Theilman and Hunt, 2016)

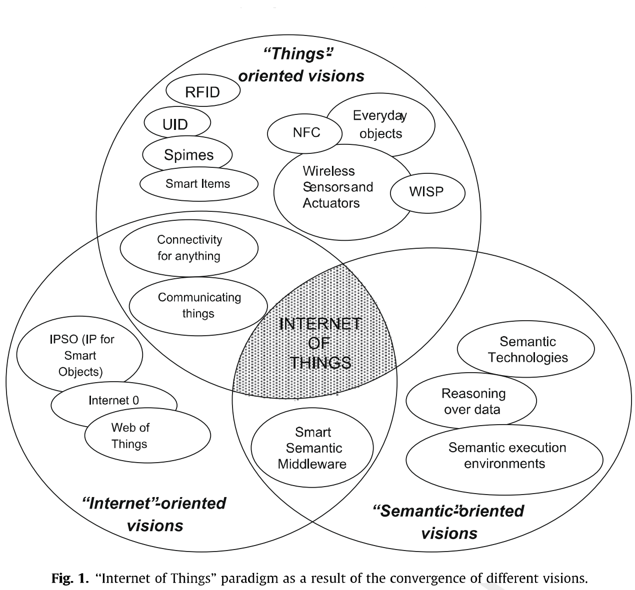
implementation, trust and privacy - that need to be addressed (Dolin, 2006; Punie et al., 2006; Michahelles, 2008; Wiesmaier and Kikiras, 2015). This leads to the challenges of the interdisciplinary aspect of this phenomenon. Yoo (2010) has raised the question of the challenges IoT brings to their research communities and their specific research fields. For example, for the field of information systems (IS), which often puts computers at the centre of its discourse (Orlikowski and Iacono, 2000; Benbasat and Zmud, 2003), the introduction of IoT most likely suggests that computing will take place on the periphery of other activities. Thus, the challenge for researchers in the field of IS would be to extend their field of enquiry beyond pure computing into real world systems (Yoo, 2010). Another concern is the often narrow focus of research in different fields. For example, research threads focusing more on a development and architecture of identification technologies, let us say RFID (Zhang et al., 2010; Mitton and Simplot-Ryl, 2011), would rarely discuss issues concerning growth and system development for sensor based network devices (Atzori et al., 2010; Chen, 2012). This could most likely be explained by the fact that technology centred research is often rooted in a specific use of technology. However, there is growing evidence of more integrated approaches, at least in terms of technology (Kortuem et al., 2010; Li et al., 2015; Ray et al., 2016).

Social challenges include abandoning the tendency to foreground the human role in the overall development. This is best illustrated by the ambient technology discourse and the vision of technological disappearance, which as Kranz et al., (2010a) argues creates the *Invisibility dilemma*[29]. By augmenting everything around us, we are faced with a need to reformulate our sense of selves in space and time, and if everything that makes such space is mediated and invisible, we lose points of reference and with it, the sense of personal agency. As Kranenburg puts it, we lose "the ability to read data as data is what makes new beginnings" (Kranenburg, 2008:11). Rob van Kranenburg, one of the founders of the Internet of Things Council in the Netherlands, borrows from the Socratic *Theoria*, *Techné* and *Praxis*, arguing against the very concept of disappearance as such a ubiquitous concept excludes *Praxis*, the

29 'When embedding information and interfaces into objects, a vital design element is to hide this augmentation and leave the original function, look, and feel the same. However, this physical disappearance and embedded sensing, actuation, and interaction can affect the user's perception and lead to the invisibility dilemma. Users must still be able to identify digitally enhanced artefacts known and used in everyday life as more potent than meets the eye. In addition, users must recognise this added value to accept and use such artefacts' (Kranz et al., 2010a:51).

domain of knowledge acquisition (Kranenburg, 2008:10). As an advocate of Bricolabs, he uses the example of a car and a recent view that “as a citizen, you can no longer fix your own car, because it is software driven” (Kranenburg, 2008:23)[30]. As he puts it, if one believes in an invisible future of computing “you have lost the very belief in a situation in which there are no professional garages, no just in time logistics, no independent mechanics, no small initiatives” (Kranenburg, 2008:23).

This ongoing discussion between technology centric or human-centric approaches to IoT development is best illustrated by the few attempts to map out the IoT paradigm. In their thorough survey of over 70 different IoT projects, Atzori et al. (2010) tackled the issue of the cross-disciplinary nature of the IoT paradigm by mapping out the convergence of different research fields and visions representing perceptions of each field (see Fig.4).



2. Atzori’s et al., Internet of Things paradigm, 2010

While this survey mapped out the technological paradigm of IoT, some argued it ignored human agency. There were a growing number of researchers who called out for more human-centric development approach (Combetto, 2006). Pointing out that the Internet of Things is not the Internet of People, Uckelmann et al. (2011) suggested that the Internet of People will link to the Internet of Things. As a result,

30 See also Grossman (2017) on the latest public demands for “Right to Repair” legislation.

they developed their own diagram of what they believe will be all of the possible fields that should overlap in order to cover the ‘real essence’ of the Internet of Things (Uckelmann et al., 2011).

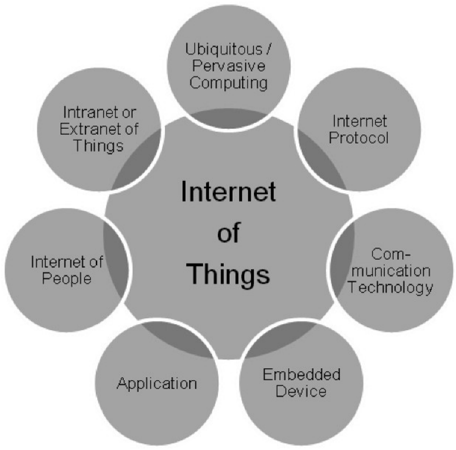


Fig. 1.2 Overlaps of the Internet of Things with Other Fields of Research

3. Uckelmann et al., Internet of Things paradigm, 2011

While these two approaches still dominate the academic research of IoT, it is notable how much recent research is coming out of China and India. For example in 2014, inspired by concepts and research of the human cognition process, Wu et al. (2014) proposed the operational framework for what they called the Cognitive IoT (see Fig. 6) (Wu et al., 2014). In China, the first strategic program in the field of IoT was put forward in 2009 and today research in this area is mostly supported by the state-supported program 973 (Ma, 2011). However, at the end of their proposed CioT proposal researchers pointed out that just like with the general development of IoT there are several major research challenges and open issues. The major issue for this research paradigm, they suggested, was the practical application “to process the obtained massive sensing data that can be of mixed characteristics, including heterogeneity, high-dimensionality and nonlinear separability”. (Wu et al., 2014:13)

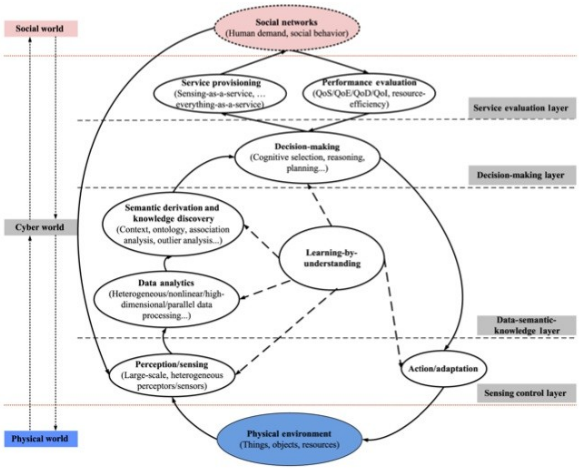


Fig. 1. Framework of CIoT.

4. Wu et al., Cognitive IoT, 2014

As these mapping attempts illustrate, current research and dominant discourse in the field of IoT, was mostly located in technological and network research frameworks. However, as next section explores, the heterogeneous nature of the subject creates a great deal of uncertainty - what some term 'fuzziness' in IoT discourse. The integration of physical and virtual worlds brings to the fore issues of heterogeneous nature, uncertainty and fuzziness that extend to all of the domains involved (Schmidt, 2003; Foth, 2008; Mendel et al., 2008; Agrawal and Das, 2011).

2.2. Fuzziness in the IoT Domain

The concept of fuzziness is often explored in the contexts of science, mathematics and system development (Kusko, 1993; Tanaka, 2007). It is frequently associated with the early stages of the innovation processes due to the “high perceived variability and low perceived analysability" of the task at hand (Souder and Moenaert, 1992:486). In the context of IoT, the fuzzy effect in development approaches, as some have argued, extends to the very name of the phenomenon. In their survey Atzori et al. (2010) pointed out that:

> *The reason of today’s apparent fuzziness around this term (IoT) is a consequence of the name ‘Internet of Things’ itself, which syntactically is composed of two terms. The first one pushes towards a network oriented vision of IoT, while the second one moves the focus on generic ‘objects’ to be integrated into a common framework. (Atzori et al., 2010:19)*

The saturated space of IoT inhabits diverse elements and complex relations between the fields of research, both in terms of academia but also within the industry, business, and fields of social science and citizen initiatives. To achieve the desired vision of the connected world would require many elements to combine, be these technological, managerial or social. This nomenclature, while most likely evoking a different kind of existence for each player, has still managed to mobilise all those diverse fields. One could ponder why, for example, it is IoT rather than ubiquitous computing that is driving the discourse across the fields[31]. As my study will explore some of the success of the emergent IoT paradigm could be down to the very ambiguity of the term but also to its empowering concreteness with which it depicts the two elements, thus making them 'visible' in our perceptions. Ambiguous as it is, the concept of 'thing' is also very common, as we all have some perception of what 'the thing' is. Likewise, I would argue, it is the ease with which the term evokes the image of the Internet that places the idea of the network at the centre of the phenomenon. The following sections will explore both the perspectives of institutional researchers and those on or outside margins of established academic or commercial settings.

2.2.1. The Network Premise

Information networks have dominated our lives for more than twenty years. As many scholars in the field of Internet culture have shown, information networks have altered our sense of time and space and shaped our economy and culture (Freeman, 2000; Terranova, 2004; Benkler, 2006). Likewise, our general sense of being in the world has been moulded by digitally mediated realities (Negroponte, 1996; Hayles, 1999; Mazzarella, 2004; Axel, 2006). In 2011, Cisco published the report in which IoT was named a Network of Networks (Evans, 2011). This network of networks perspective was put into motion around 2009 when EU Commission created an action plan in which the Internet of Things was seen as a general evolution of the Internet “from a network of interconnected computers to a network of interconnected objects”[32] (Sachs et al, 2010:244).

31 This can be seen as a rhetorical question, as those working on ubiquitous computing paradigm, with its aspects of invisibility, suggest that it will be the next stage of IoT (Hindi, 2015).

32 European Commission: Internet of Things – An action plan for Europe (COM, 2009).

In such an evolutionary context, IoT is viewed as an extension of the Internet. Thus, on all technical levels, infrastructure, application and adaptation, the IoT inherited both the complexity of Internet services and its structure (Zhang et al, 2010). Likewise, such perspective of inheritance indicates that the IoT will acquire some of social traits of the Internet thus further affect the social fabric and the everyday. However, unlike the Internet, the IoT needs to deal with deep the heterogeneity (Hachem, 2011) that comes with not only a rich variety of fragmented devices and technological formats but also with the diversity and properties of the physical world - such as distance, materiality and local characteristics of space and contexts. As discussed above, this diversity of technologies - and subsequent industries and research fields involved - has been one of the key reasons why there has been a slow development of IoT systems and IoT specific standards.

While much of IoT is still being constructed - or, in other words, in a state of becoming - at the time of this study, it became evident that it was the emerging reality of platforms and their role in network structures that gain the significance in this debate. It was the aftermath of the first dot-com bubble in late 2001 that, as Tim O'Reilly and John Battelle suggested, "marked a turning point for the web"[33]. The year 2005 was significant; not only did they coin the phrase 'the web as platform' and lay out the principles governing the Web 2.0 framework; but today's most influential domain, that of social networks, acquired their foundational principles.

At its onset, the Web 2.0 was often described as a meaningless marketing buzzword (O'Reilly and Battelle, 2005:1, Brodkin, 2007:1) or a business management strategy (Lovink, 2011:6). Nevertheless, as O'Reilly and Battelle pointed out in their articulation of Web 2.0 framework, there were some observable differences between what could be identified as Web 1.0 and Web 2.0 companies and their chosen design approaches. As they highlighted, the most fundamental features were the following: the focus on delivering 'software as service' rather than as a stand-alone product (a characteristic of Web 1.0); control and ownership of a specialized database; lightweight programming models; SOAP (Simple Object Access Protocol) stack; HTML; an approach sometimes referred to as REST (Representational State Transfer); use of RSS technologies; and most importantly "the power of the web to

33 http://www.oreilly.com/pub/a/web2/archive/what-is-web-20.html#mememap

harness collective intelligence. Network effects from user contributions are the key to market dominance in the Web 2.0 era" (O'Reilly and Battelle, 2005:2).

Most of the current IoT ecosystems and applications already use existing Internet-based technologies and services, and firmly sit within the Web 2.0 framework. However, debates about the IoT and its relation to the Internet and world wide web are ongoing. That has led some to argue that IoT should be seen as a special set of Internet applications leveraging on the World Wide Web and its many technologies and standards such as URIs, HTTP and REST[34] (Schmidt, 2003; Fleisch, 2010; Sachs, 2010; Trifa et al., 2011). Arguing for Web of Things concept and applications, Guinard et al. (2011), pointed out that the open characteristic and simplicity of the WWW protocol and technologies are easy to reuse and to adopt thus asserting the current extensive use of REST[35] architecture and utilisation of Application Programming Interface (API). The current adaptation of several web and remote APIs offers numerous beneficial elements, among them the architecture shields and stacks of underlying applications that allow technology platforms to evolve independently from each other.

As sensor nodes and wireless sensor networks become part of the overall Internet, there are also growing concerns about the extremely different data traffic characteristics that are imposed on the overall network. As noted already, the IoT creates large amounts of automated data, various types and sizes of data. This, besides other factors, has led to the vast expansion and adoption of the cloud computing paradigm that not only promises to resolve data storage issues but also centralises the management of issues, such as data protection, archiving and deletion (Barnatt, 2010; Erl et al., 2013). However, as Guinard et al. (2010) pointed out, IoT-specific cloud platforms such as SenseWeb and Pachube (now Xivey, the platform at the centre of this study), while providing people with a framework for sharing their sensor readings using Web services, also transmit data to a central server, which they find problematic. Unlike their proposed Web of Things, they argue, "these approaches are based on a centralised repository and devices are considered as

34 In practice, standards such as SOAP and WSDL might be too expensive and complex (Sachs2010).

35 "The essence of REST is to focus on creating loosely coupled services on the Web so that they can be easily reused. This makes it an ideal candidate to build a 'universal' architecture and Application Programming Interface (API) for smart things." (Guinard et al., 2011)

passive actors only able to push data" (Guinard et al., 2010:2).

The debate on network architecture, its centralised or distributed nature, open or closed character, has been pivotal across the development of the Internet and will continue in the era of IoT. The Internet is 28 years old (2017) and as its creator, Tim Berners-Lee said "it has been a recurring battle to keep it open" (Berners-Lee, 2017, para 1). While there are serious attempts to tame the Internet into a closed proprietary system with its clear national borders and controllable private network monopolies, the struggle for Net neutrality is still at large and evolving[36].

The struggles in the network paradigm are both social and technological. As Galloway (2004) has pointed out "Without a shared protocol, there is no network" (2004:12). In his interpretations[37] of the role of the protocol, Galloway described it as "distributed management system that allows control to exist within a heterogeneous material milieu" (Galloway, 2004:8). In his rather detailed analysis of materiality, form, and power of the protocol, Galloway argued that no matter how much the network metaphors are scattered around every other sphere of our lives, or how democratic or non-hierarchical they might sound, distributed networks, computing technologies and, above all, the protocols governing their principles, are the new "apparatus of control" in our society. More recently, other elements affecting power relations through software levels have been explored. Most notably, scholars have turned to the analysis of the emerging role played by algorithms (Christian and Griffith, 2016) or the nature of applied mathematics in a context of Big Data (O'Neil, 2016). All these will have a role in management and orientation of power and control within the IoT paradigm.

Furthermore, as critics of emancipatory visions of the Internet that has dominated the net since the early '90s have pointed out - or what Richard Barbrook and Andy

36 See Rogers (2017) on latest developments in December 2017.

37 With his background in critical media theory, Alexander Galloway was rather critical of ANT. In his essay 'The Poverty of Philosophy' (2012), echoing the ideas of Marx's historical materialism, he pointed out that "the true poverty of the new realism is not so much its naïve trust in mathematical reasoning and object-oriented architectures but its inability to recognize that the highest order of the absolute, the totality itself, is found in the material history of mankind" (Galloway, 2012).

Cameron (1995) called the Californian ideology, Edward Snowden's revelations (2013) about the NSA's data collecting practices shows that the Internet today is far from advancing the cause of human liberty[38]. Rather, Snowden has revealed the global surveillance apparatus, an industrial-scale espionage that works in the service of the state and corporate despotism. These two perceptions of the Net, as a space for public or civil society and as a space of mass surveillance are likewise at the core of the discussions surrounding the Internet of Things phenomena. If built as a next layer of the Internet, IoT not only inherits this uncertainty but can also further or degrade the developments towards each of these efforts.

In conclusion, from the network perspective, the IoT is not only viewed as the network of all networks but also considered as an evolutionary stage in the development of network information technologies. Technically, the IoT is being built by appropriating many Web 2.0 applications and, today, the whole paradigm is openly fostered as a business management strategy (Shuen, 2008; Lovink, 2011; Allen, 2015; Ruparelia, 2016; Rossman et al., 2016). Socially, if viewed in evolutionary terms, the IoT, like the Internet, will further penetrate into our everyday life and shape our experience of the physical world. By connecting objects and things around us, it will shape the materiality of our environments and our perceptions of them. However, as the next section explores, it is the very process of defining what 'the thing is' that contribute the the fuzziness in IoT domain.

2.2.2. The Thing: A Critique

As noted already, the number of objects on the Internet exceeded the number of humans in 2008 (Evans, 2011). Besides computers and mobile screen technologies, the most common objects online today are television sets, cars, transport vehicles, fridges and washing machines. However, such interconnected concepts as ‘anything, anywhere, anytime’ are still far from being achieved. It can, however, be argued that the last 10 years have seen an increase in the variety of connected objects that is

38 For the full list and description of revelations see: https://en.wikipedia.org/wiki/Global_surveillance_disclosures_(2013%E2%80%93present) and https://www.theguardian.com/world/video/2013/jun/09/nsa-whistleblower-edward-snowden-interview-video

driven by the technological developments of the IoT framework (ubiquity of networks, increase in data storage and decrease in processor size and the development of applications that can benefit from objects being identifiable and/or locatable through different mechanisms (Grønbæk, 2008; Fleisch, 2010). While Atzori et al. (2010), as noted above, interpreted the word 'thing' as a 'generic object' in a context of IoT terminology, I would argue there are further issues related to the very word 'thing', as it not only relates to the 'device' that is connected to the Internet but also the phenomena or 'the thing' that is measured or sensed.

Thus, the use of the word 'thing' opens up a larger phenomenological issue that the framework of IoT might need to address in future. At this stage it might also be useful to clarify the use of the term phenomenology in this thesis. Today, phenomenology is often understood in two ways, either as a movement in the history of philosophy that flourished in the early 20th century, - most notably in the works of Husserl, Heidegger, and Merleau-Ponty - or as a disciplinary field in philosophy, as the study of structures of experience, or things, or 'phenomena' as they appear in our experience. In other words the ways and the meanings things have in our experience, studied from the subjective or first person point of view[39]. While referencing the former, it is the latter, I argue, that will be of importance in the context of emerging IoT phenomena that aims to make visible what was previously hidden.

It was Heidegger (1971) who highlighted the ambiguous meaning of the two words *the thing* and *the object.* To exemplify his argument Heidegger used the example of a jug. As he argued, while *the object* jug might be the walls, base and its void that were moulded in action by the potter who formed it, the *thingness* of a jug actuates in the act of gathering, holding or pouring, thus aligning the meaning of 'the thing' with the act or performativity. Through searching for the linguistic origin of the word ‘thing’, or in old German ‘dinc’, he pointed out that it is not only synonymous with an object but rather it means gathering to contest a matter, or for purpose of dealing with case

39 There are number of concepts frequently used in phenomenological analysis. For example, the Kantian notion of 'thing itself', Husserl argued, always is shaped by the subjective – work of thoughts in surrounding 'life-world' (Husserl. 1970/1992:295). 'Life-world' is perceivable, intuitive and immediately experiential in space and time (Husserl. 1970/1992:48,103,168). There are other concepts that have informed this thesis, most notably: 'intersubjectivity' and 'the world'. Of relevance are also Heidegger's (1962) in depth analysis of 'being', and Merleau-Ponty's 'chiasm', explored through sensible and sentient aspects during self-touch and 'flesh', ontological continuity between subject and object among sensible things in general (Merleau-Ponty 1964:182/138)

or matter. Such use of the word thing is still preserved in English ‘He knows his thing’ or 'The thing is ...'. (Heidegger, 1971:175)

If we embrace this broader meaning of the word in the context of the IoT, the *thing* is not only anything that is real (Merleau-Ponty, 1962) but also performative acts. Thus, the meaning of 'the thing' could include living things (cats, dogs and babies, already tagged), things we do (our movements in space, already tracked), it also includes that thing – the environment (public spaces or the air we breathe), buildings, which like Heidegger’s jug is a vessel for the void it holds inside (connected buildings and smart cities) and the IoT itself (subsequently the world itself).

Furthermore, *the thing* is most likely something that is local, experienced or in other words close to human subject, rather than being out there, what networks represent. This locative element of 'the thing' has led Yoo (2010) to suggest that we should consider phenomenological thinking in the context of IoT and recognise the centrality of embodied human experience in this context[40]. Thus, before we address the historical discourse that has fostered the developments in what I will here call a critical 'thing' perspective, let us briefly look at the key suggestions made by the phenomenologists in the past.

The principal founder of phenomenology Edmund Husserl was preoccupied with studying the units of consciousness in order to understand the principles of cognition. He argued that our consciousness is made up of "intentional acts", and that such acts are almost always directed towards objects, or what he called the "intentional objects". However, as it is the intentionality of a conscious perceiver that is directed towards these objects, they are grasped only partially or incompletely. Thus "intentional objects" are subjects of “modalities of time, such as perceptually present, past in memory, with what meaning-content or what type of object etc.” (Husserl. 1970/1992:241).

40 Yoo draws on Dewey (1934) and Merleau-Ponty (1962) conceptualisation of human experience as an interaction between body and the environments that are characterised by “four dimensions: time, space, other actors, and things (including the natural world)”. By computerising these four areas of experience, Yoo suggests that “Humans will no longer experience computing as something that is out there, but rather they will live in it” (Yoo, 2010:219-220).

Merleau-Ponty took Husserl's argument further. In his *Phenomenology of Perception* (1945) and later in *The Visible and the Invisible* (1968). Merleau-Ponty insisted that "perception" is always already situated and embodied. Thus, he argued that both object and subject are dependent on situatedness in the world and, therefore unfree from social and political entanglements. However, while we can experience things “in themselves”, as they really are in the mind-independent world, Merleau-Ponty argued it is a kinship between the sensing body and sensed things that makes their communication possible (Merleau-Ponty, 1968/1992:133). He articulated this in terms of a 'chiasm[41]', a crisscrossing or a bi-directional exchange between the body and things, and 'flesh', a visible and the metaphysical structure that we share with the world and objects in it. “My body is made of the same flesh as the world (it is a perceived), and moreover that this flesh of my body is shared by the world, the world *reflects* it, encroaches upon it and it encroaches upon the world” (Merleau-Ponty, 1968/1992:248).

This corporeal aspects of our being in the world or embodied perception is what makes a house into ones home, for example. “The things - here, there, now, then - are no longer in themselves, in their own place, in their own time; they exist only at the end of those rays of spatiality and of temporality emitted in the secrecy of my flesh. And their solidity is not that of a pure object which the mind soars over; I experience their solidity from within insofar as I am among them and insofar as they communicate through me as a sentient thing” (Merleau-Ponty, 1968/1992:114). The things are never just 'generic objects', they are not a simple tool, but rather they are directly shaped by our perception as much as they shape and transform the lived experience itself. Thus, I would argue, when thinking from a thing perspective, it is this entanglement with an individual uniqueness aspect of human perception that brings further complexity and fuzziness to IoT system deployment.

On the other hand, this very embodiment can also bee seen as a point from which the intersubjective understanding of things can be derived. If two people stand next to each other and observe the same thing, their 'right', 'left', 'here' and 'there' would be identical and 'the thing' could thus be perceived from such an *egocentric* viewpoint

41 “a 'chiasm' or crossing-over (the term comes from the Greek letter chi) which combines subjective experience and objective existence” (Baldwin, 2004).

that could be similar for both. Furthermore, there are two other modalities that can assist us with articulation of the 'intersubjectivity'[42], another term used by phenomenologists to describe the perception of objective world. First is language; in particular, the way new ideas and expressions emerge and get assimilated into language and institutional structures. The good example, that will be discussed later on, is the phenomenon of naming things[43]. The second modality is that of a work of art, be it a work of literature of plastic arts. Roman Ingarden, a founder of phenomenological aesthetics argued that because works of art are not autonomous, fully determined objects they are dependent for their existence on the intentional acts of their creators and of their viewers/readers; or in other words, they have 'intersubjective' life. (Ingarden, 1931:331–55).

As it was seen in the previous section of this chapter, the process of naming the emerging phenomena we now address as IoT, has an evolving history. The same can be said about the naming objects within the IoT framework. In discussing the *thing* perspective in the following, I will thus focus on previous work in art and literature, besides more traditional frameworks of technological development, that has contributed to this process. I will argue that it is these works that not only have advanced the active processes of classification and 'naming' of things, objects and actions in IoT context, but has also contributed to this very phenomenological enquiry and intersubjective understanding of the IoT itself.

In a search of history and early examples of connected *things*, artefacts or objects, it becomes apparent that, just like with other scientific discoveries, technological innovations are often driven either by laziness, accident or creative urge. For example, the earliest instance of the connected thing is often assigned to the Carnegie-Mellon University's Computer Systems departments Coke machine that

42 Intersubjectivity - "in whatever way we may be conscious of the world as universal horizon, as coherent universe of existing objects, we belong to the world as living with one another in the world/-/ valid for our consciousness as existing precisely through this 'living together'" (Husserl 1970/1992:108), "world shared in common" (Merleau-Ponty 1964: 62/39, 67/43). "From a first-person point of view, intersubjectivity comes in when we undergo acts of *empathy*. (Stanford Encyclopedia of Philosophy, 2003, Para 7).

43 Merleau-Ponty addressed this aspect by the example of a child's learning process. "for the child, the thing is not known until it is named, the name is the essence of the thing and resides in it on the same footing as its colour and its form. But of course before the thing was named, it had some kind of existence in consciousness, which was evoked in the process of giving it its name. That existence was itself already a kind of interpreted existence through the way the thing-to-be-named was already used and referred to in the exchanges of the life world" (Merleau-Ponty, 1962:177).

sensed how many bottles were present, and in the early 1980s became networked into the university's standard ARPANET. As Tom Lane, a computer scientist and one of the ex-students at Carnegie-Mellon University recalls, the motivation to wire up the Coke machine was driven purely out of inconvenience caused by relocation of the department “further away from the main terminal room where the Coke machine stood. It got rather annoying to traipse down to the third floor only to find the machine empty” (Lane, 2005, para 3). Similar motivations led the scientists working in University of Cambridge Computer Laboratory to develop the very first webcam (Stafford-Fraser, 1995). Initially connected to the internal ATM network (1991) and later to the Internet (1993), they install the cam to monitor The Trojan Room coffee pot: “we only had one coffee filter machine between us, which lived in the corridor just outside the Trojan Room. Some members of the 'coffee club' lived in other parts of the building and had to navigate several flights of stairs to get to the coffee pot; a trip which often proved fruitless.” (Stafford-Fraser, 1995, para 2). The Trojan Room coffee pot later was named as “one of the first internet stars” by the Wired magazine[44] as it reached more than 2 million hits by 1998.

While these two are examples of early attempts to monitor their things by computer scientists, in the mid 1990s it took an artist in residence to create one of the most often cited early examples of ambient or calm technologies that explore the performative understanding of what things can do. In 1995, at the Xerox PARC Computer research lab, artist Natalie Jeremijenko under the supervision of Mark Weiser, created an art installation entitled Live Wire that is now more broadly known as Weiser's Dangling String. The installation was made up of a LED cable that was hung at the corner of a systems room, and which lit up and moved in relation to the amount of Internet traffic (Weiser and Brown, 1995). Thus, it was no longer only a wire but rather an ambient interface that relieved system administrators from staring at screens, in other words, it became, perceptually, an intersubjective thing in its act of doing something.

As noted already, the concept of the Internet of Things was developed in the context of tracking technologies such as barcodes, RFID, and EPC. Equally important was the demilitarisation and development of mapping and geo-spatial technologies

44 See the original article here: https://www.wired.com/2001/03/farewell-seminal-coffee-cam/

(GPS). With the spread of the Internet and proliferation of consumer technologies, the innovation and development of the variety of new tools and applications by the early 2000s could be accomplished by anyone with an appropriate level of curiosity and know-how. An example here could be the developments of Google Maps, by one of, at that time, the emerging industry giants, and OpenStreetMap, a collaborative open source project that galvanised many to record and share GPS data as they walked the streets of their cities. Mapping and computation of geo data flows in commercial mapping domains were conducted under name of 'location-based services' while on the margins media artists, theorists and activists worked under the concept of Locative Media[45], all of these could be seen as precursors of the IoT. Mapping *the thing* in this context can be best illustrated by the Christian Nold's *Bio-Mapping* project (Nold, 2009) that tracked and visualised people's emotional responses to the external world[46]. *Bio-Mapping* is particularly interesting work as it not only forefronts the emotions as *a thing* in a shared network, but also makes visible the perceptions and the role it plays in the ways we navigate and perceive space and things around us.

Looking back into the historical narrative of IoT, the year 2005 was a significant[47] one, as networked object vision entered not only the industry establishment, with the first introduction of IoT in the report published by the International Telecommunication Union and launch of already mentioned Web 2.0 framework, but also the more popular public discussion. In 2005, not only the O'Reilly Media began publishing Make, a quarterly magazine that became a central organ of makers movement[48] and a number of books were published with the term "Internet of Things" in their titles[49], but also a Golden Nica award at the largest new media arts festival, ARS Electronica in Linz, was awarded to the project MILK[50].

45 Locative Media movement was set in action by Karlis Kalnins and Marc Tuters during the Locative media workshop in Karosta, Latvia in 2003 (Smite, 2011).

46 More on Christian Nold's project here http://www.biomapping.net/

47 The UN report on the state of the IoT in 2005 suggested: "It would seem that science fiction is slowly turning into science fact". The Economist (2008) also pointed out that "several commentators name the year 2005 as date for the rebirth of modern open hardware movement: the work began on devices such as the RepRap (a rapid-prototyping machine) and the TuxPhone, an open, Linux-powered mobile-phone. It was also when Sun Microsystems, a computer-maker, decided to publish the specifications of one of its microprocessors" (The Economist, 5 June, 2008).

48 See: https://en.wikipedia.org/wiki/Make_(magazine)

49 The following books were published in 2005: *Das Internet der Dinge* (Fleisch and Mattern, 2005); *The Internet of Things* (ITU, 2005); *Shaping Things* (Sterling, 2005); *Spychips: How Major Corporations and Government Plan to Track Your Every Move with RFID* (Albrecht, 2005).

50 MILK project is accessible online at http://www.milkproject.net/ Last Accessed 1 April, 2017.

Significantly, it was Bruno Latour, author of Actor-Network theory, who first exhibited MILK, a project by Ieva Auzina and Esther Polak, in his *Making Things Public*[51] exhibit at the Center for Art and Media (ZKM) in Karlsruhe the same year[52]. The work of a group of Latvian and Dutch media artists used GPS trace-routes to follow the path of milk from its origins in the udder of a cow in rural Latvia to a cheese vendor in the Netherlands. While inspired by romantic landscape art, the work was presented as interactive installation of GPS maps, augmented with intense media content and human stories and through them "suggested a powerful vision of how locative technologies could allow one to more fully understand how products are commodified and distributed through the actions of global trade." (Tuters and Varnelis, 2006, para 15)

The same year during the first season of Node.L media arts festival in London and later in ICC in Japan, the London-based architect and designer Usman Haque showcased his *Evolving Sonic Environment III*, an 'acoustically-coupled analogue neural network, consisting of a society of devices whose behaviour collectively changes in response to the pitch ascendancy or descendency that each one detects'[53]. *The Environment III* consisted of numerous sonic devices, which Haque saw as a society of devices, all producing their own high-frequency sound while interacting with each other and the changing environment around them as the audience entered the room. Thus, the *Environment III* was not only the project that appropriated his *EnviromentXML*, an online space or environment as propagated by its title, that enabled people to tag and share remote real-time environmental data, but also the visualisation of an environment in which autonomous *things* act in a relational accord, and in response to a human subjects. *EnviromentXML* was a precursor of what later became the first IoT platform Pachube, and this vision of IoT as an environment that responds to human subjects, as the empirical part of this thesis will explore, was one of the cornerstones on which it was built upon.

While media art was at the forefront of making the visions of the coming IoT paradigm more tangible and experiential, it was the writers who articulated and

51 *Making Things Public*, curated by Bruno Latour and Peter Weibel archive site can be viewed here: http://on1.zkm.de/zkm/stories/storyReader$4581 Last Accessed on 1 April, 2017.

52 The ZKM site here: http://zkm.de/ Last Accessed on April 1, 2017.

53 The Usman Haques website for project Evolving Sonic Environment can be viewed here: http://www.haque.co.uk/evolvingsonicenvironment.php Last Accessed on 1 April, 2017.

named these new ideas in words and language. Books published in 2005 were the first attempts to identify and name this new breed of objects. As already mentioned, the *International Telecommunications Union's report* (see Sundmaeker et al., 2010) advocated the holistic approach to IoT development by suggesting that the Internet of Things will connect the world's objects in both a sensory and intelligent manner. The new concepts of things covered in the report included ‘tagging things‘ (item identification), ‘feeling things‘ (sensors and wireless sensor networks), ‘thinking things’ (embedded systems) and ‘shrinking things‘ (nanotechnology) (Sundmaeker et al., 2010).

However, I would argue it was a small pamphlet published by science fiction writer Bruce Sterling, *Shaping Things (2005)*, that expounded his vision of the future IoT in a form of a wake up call for contemporary product designers and engineers of the techno-social world that captured the broader public imagination. Though just a few years earlier Sterling was tackling the visions of the ubiquitous computing[54] from the system perspective, in *Shaping Things* he turns towards complexities of the thing itself. Sterling came up with the term ‘spime’, a mash-up of the words ‘space’ and ‘time’ to describe an object or a thing that is not only defined by its identity and relationality but is also always on, recording its life, location and relations from its cradle to grave. It is a thing that is more digital than material:

> *Spimes are manufactured objects whose informational support is so overwhelmingly extensive and rich that they are regarded as material instantiations of an immaterial system. Spimes begin and end as data. They’re virtual objects first and actual objects second. (Sterling, 2005:11)*

While *spimes* might be still just a fruit of imagination and never really entered the popular lexicon, Sterling not only predicted how the presence of *spime,* like things, might affect our relationships with our possessions, but also the changing relationship between space, time and the material world. Thus, he not only brought forward the phenomenological argument of 'intentional objects' but also created the intersubjective vision of the world changed by an integrated IoT system. Objects are

54 Famously in his essay *Tomorrow Now: Envisioning the Next Fifty Years* (2002), Sterling stated “I favor ubicom. Ubicom sounds very ugly and humble. The vision I describe here as ubicom is not strictly ‘ubiquitous’. Ubicom is best understood as a very dumb and homely kind of digital utility, maybe something like air freshener or house paint.” (Sterling, 2002)

no longer seen as just material goods with fixed states or 'generic objects', but rather as relational to human activity, shifting in space and time as well as in their own meaning. Furthermore, Sterling highlighted the serious semantic challenges that will come with naming and tagging of all connected things. *"No name, no SPIME"* he states.

> *The labels that we attach to objects are never identical with the phenomenon itself; the map cannot be the territory. There is a frail, multiplex relationship between labels and materiality. (Sterling, 2005:77)*

The other subtle suggestion made by *Shaping Things* was the need to design any future technology with sustainability in mind, or what Mark Tuters later dubbed as Sterling's call to "détourne the Internet of Things itself to become more fully aware of the ecological role of objects in the world" (Tuters, 2006, para 16). Many IoT visions evoke the idea of future sustainability. However, they are often discussed in a context of supply and demand that the overall system will be able to manage, rather than in terms of digital waste created by the short lifespan of an electronically enhanced object or in terms of mineral mining required to produce the electronics. While in 2017 there seems to be more awareness of these issues, in 2005 Sterlings suggestion seemed rather far-fetched: "At the end of its lifespan the SPIME is deactivated, removed from your presence by specialists, entirely disassembled, and folded back into manufacturing stream" (Sterling, 2005:77).

A year later Julian Bleecker from Nokia Design Studio, in response to Sterling's *spime,* launched his own manifesto entitled *A Manifesto for Networked Objects - Cohabiting with Pigeons, Arphids and Aibos in the Internet of Things*. There he came up with the *Blogject*, "a kind of early ancestor to the Spime" (Bleecker, 2006:2). He made a differentiation between the things connected to the Internet and things participating within the Internet.

> *Blogjects don't just publish, they circulate conversations. Blogjects become first-class a-list producers of conversations in the same way that human bloggers do - by starting, maintaining and being critical attractors in conversations around topics that have relevance and meaning to others who have a stake in that discussion. (Bleecker, 2006:4)*

As Corino et al. later pointed out, Bleecker extends Sterling's *spime* concept by adding agency to its characteristic (Corino et al., 2011). Bleecker's *blogjects* can provoke action and participate by blogging their status and surroundings. They have an assertive voice within the social web as they have the ability to affect change or we might act and react to their messages. What Bleecker initiated in his discussion was the suggestion that the IoT should really be considered in a public context, thus evoking the possibility of IoT to be developed within an open framework. For example, he used an instance of travel luggage that is traced, derailed and found, and CCTV cameras that record and upload information online. Using as an example a mapping project iSee, developed by Institute for Applied Autonomy (2002)[55], he suggested the possible *détourne* that open IoT could take. "iSee contains a DIY database of surveillance cameras in the supremely pedestrian New York City and some similar route finding software to that used by Google Maps, and plots routes so as to avoid the maximum amount of exposure to cameras" (Bleecker, 2006:11). Thus, Bleecker concludes that if an object were able to comment on the world around it, and through that affect change, then the agency between subject and object, human and non-human would be transformed. Commenting on these naming attempts and developments of technology since 2005, Santucci (2010) suggested that the *twitterjects* or objects that tweet could also be added to this history of naming things in the IoT context.

What can be observed in all these naming attempts, be it science fiction or early research papers, is the shift from the conception of a thing in itself with its inherent passivity that gets activated by the presence of human perception to an agency of a thing as an active thing out there. This autonomous aspect of things where things actively participate in constitution and re-constitution of time, space, place and cultural forms through their interactions, is still largely unexplored and exists only in a theoretical and linguistic articulation[56]. However, there are already few early

55 Project site could be accessed through https://web-beta.archive.org/web/20120526005113/http://www.appliedautonomy.com/isee.html

56 It is worth noting that the year this thesis was submitted there were a number of connected things that already act in what could be argued is an 'autonomous' manner. While I would not suggest that we have seen an active element of their agency, their autonomy does seem to manifest itself in moments when something goes wrong and hence the emerging issues with this paradigm emerge. In 2018, a self driving car killed a pedestrian, Amazon's Alexa, an Internet connected smart speaker and listening device, not only recorded private conversation and distributed it to a wide network of contacts, but also produced a random bursts of 'creepy' laughter. See (Wong, 2018; Wolfson, 2018) www.theguardian.com

examples, if mostly comical, out there. For example, one such twitterject Bablino, a bubble machine that spits out bubbles if its own name is mentioned on Twitter[57] was an active participant at Open Internet of Things Assembly (2012), an event that will be explored later.

However, with time and further technological developments, more pragmatic thinking has prevailed. Haller (2010), in his contemplation paper *The Things in the Internet of Things*, pointed out that one way to overcome the complexity embodied in the word 'thing' is to make a clear distinction between an object or entity and a device:

> *The distinction between entities of interest and devices is often clear – the entity of interest is the object that has some value for the observer, the device is a technical component needed to observe or interact with the entity of interest. There are, however, many cases where the distinction is more difficult. (Haller, 2010:2)*

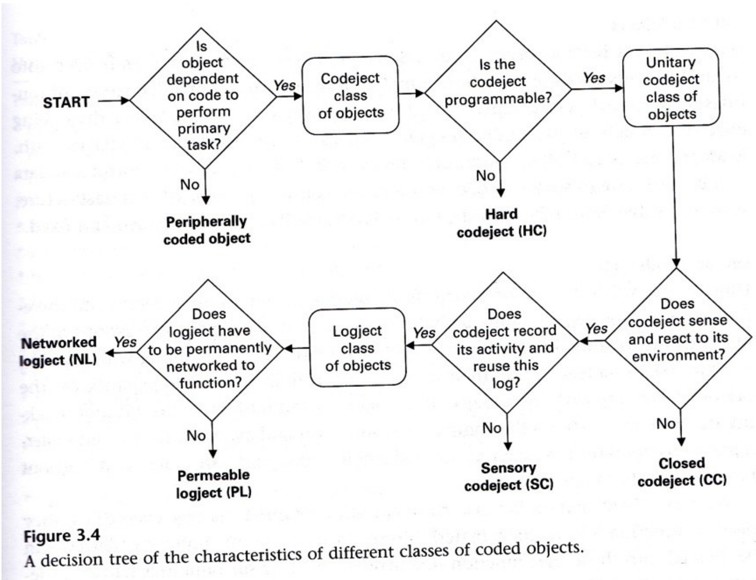
Haller elaborates that the object or entities of interest should include attributes that describe it from a user or application perspective while the devices most likely will be attached to or embedded in the entities themselves. Here he makes a clear separation between the *things* that are out there and being measured and *things* or devices that do the measurement. Devices would usually host all computational resources and the ones that make the object or entity smart. He does, however, point out that clear-cut categorisation is not always possible and such cases should be treated as special (Haller, 2010).

While the impact and relations between 'smartness' and an 'entity' or its properties is not yet much explored[58], there are, however, a number of emerging studies that have looked into ways computational devices impact our world. It has been argued that any technically enhanced device can already be articulated in terms of its technicity, its functionality and how it is experienced and, transduction, a process in which a domain taking-on-form, or by which things transfer from one state to another, sometimes repeatedly. For example, social geographers Kitchen and Dodge,

57 For the duration of Open IoT Assembly Bablino also responded on #openiot.

58 It should be noted that in 2018 there has been a number of studies that have explored device impact on an entity, most notably in a context of health and fitness monitoring. See (Davis, 2018).

(2011) developed a classification of what they called 'coded objects'. Figure 4. illustrates their five suggested distinguishable categories of coded objects. While all categories have some relevance to IoT discourse, I would highlight here the most relevant. The *Networked Logjects*[59] that "track, trace and record their usage" and the S*ensory Code/Objects* that are networked into the Internet and do additional work in the world by collecting and distributing data about the world, or what Kitchen and Dodge poetically called "capta shadows that can be analysed for emergent properties" (Kitchen and Dodge, 2011:90).



5. Classes of coded objects, Kitchin and Dodge, 2011

Furthermore, in deconstructing the meaning and materiality of a computational device, they argued for the emerging new discipline[60] and demand that the code and software should also be studied in spatial terms, or, as they put it: it demands its own space.[61] They suggested that the relational nature of the spatiality

59 "Networked logjects do not function without continuous access to other technologies and networks. Such logjects track, trace and record their usage locally, but because of memory issues, the necessity of service monitoring/billing, and in some cases a user's ability to erase or reprogram such objects, their full histories are also recorded externally to an immediate material form." (Kitchen and Dodge, 2011:59)

60 Software studies focus on the ethnology of code and how code makes digital technologies what they are and shapes what they do. It seeks to open the black box of processors and arcane algorithms to understand how software-its lines and routines of code-does work in the world by instructing various technologies how to act. Important formative works in this field include Galloway's *Protocol* (2004); Fuller's *Behind the Blip* (2003), *Media Ecologies* (2005), and *Software Studies: A Lexicon* (2008), Lessig's *Code and Other Laws of Cyberspace* (1999), Manovich's *The Language of New Media* (2000) and *Software Takes Command* (2008), Hayles's *My Mother Was a Computer* (2005), and Mackenzie's *Cutting Code* (2006) to name a few.

61 Kitchen and Dodge highlighted the emergence of new actants in digitally extended environments

in everyday life, where what they called a "code/space" emerges, operates and is experienced. In other words, code/space is embodied, through the performances and interactions of people within such space. It is constructed between people, and between people and code. They borrowed[62] the concept of transduction[63] and technicity in setting parameters for this new spatial context. As they suggested: "The reason why software can modulate the perpetual production of space is because it possesses significant degrees of technicity. This technicity is realized through the process of transduction"' (Kitchen and Dodge, 2011:72). To illustrate this process of transduction they use an example of wireless access in coffee houses. A WiFi-enabled computer in a coffee house transduces the coffee house into a workspace.

These visions of early researchers sketch out some key parameters for things in the IoT paradigm and represent some of early applications in this field. As these examples show there are three key aspects that instruct this perspective – defining what the thing is, its design process and how it articulates the unseen, be it a natural phenomenon, emotion or relations. Furthermore, the discussion between *spimes* and *blogjects* highlights the fundamental question in this debate, i.e. how much agency, on their own, do things have, if any. However, at the time my study was conducted (2011-2013), there were rather few examples of IoT things that had reached larger user base. Today (2018), with an increasing drive to *thingify*[64] every possibility and

and as geographers they insisted that "the mantra of ubiquitous computing is computation in every place" (Kitchin and Dodge, 2011:219), or in other words the place matters for them.

62 In their own references they quote MacKenzie's description of transduction. "Through transduction, a domain structures itself as a partial, always incomplete solution to a relational problem." For example, in writing, how to spell the next word, finish the sentence, structure the paragraph, and make a convincing argument. These problems are provisionally solved by some action consisting of individuations (looking in a dictionary, typing, editing, thinking, refining), thus transferring the situation from one state to another, yet also immediately creating a new problem to be solved (the next sentence)" (Mackenzie, 2003:10). The concept has also been articulated by other thinkers. For example, Gilles Deleuze discussed it in a context of individuation and actualisation process to an entity in his Difference and Repetition (1968) and work of Gilbert Simondon who has written thoroughly on this concept and defined it broadly as a dynamic operation by which energy from one element is actualized by a continuous electric relay (Simondon 2013, 82). Concept is widely used in biology as well computer science and signal processing.

63 The term was initially used by Henry Lefebvre as a possible approach, intellectual tool and a way to change the how planners think about the needs of social man. 'Transduction elaborates and constructs a theoretical object, a possible object from information related to reality and a problematic posed by this reality. Transduction assumes an incessant feedback between the conceptual framework used and empirical observation' (Lefebvre, 1995:151). However, in Kitchen and Dodge's interpretation this human ability is assigned to the new actant – code or software.

64 The term is lately, broadly used in Internet of Things development sectors, in particular within the start-up frameworks. For an example, see: '11 ridiculously easy ways to thingify your thoughts and

opportunity, there are many examples of connected devices on the market, from toasters, fridges and smart meters, to gadgets such as smart toothbrushes, smart baby monitors, smart toilets, helmets, alarm clocks and smart tires[65]. Many, however, still find that it is still hard to deploy overall integration and interconnectivity of all these 'things'. The degree of heterogeneity increases strongly on all levels be it software or hardware, of sensors/actuators components to the complex and diverse devices that integrate many components and networks (Zhang et al., 2010; Hachem et al., 2011).

Furthermore, with a proliferation of computational things, there has also been an increase in scholars who have questioned the overall suggestion of sustainability at the heart of the IoT paradigm by pointing out incremental growth in digital waste or natural resources necessary to sustain both production of electronics themselves as well as energy required for data hosting warehouses (Gabrys, 2011; Koomey, 2011). The field of social theory also seen a re-emerging interest in thing-theories and material culture, that has led some to call for an overall need to rethink the “new materialism” paradigm (Dolphijn and Tuin, 2012; Simms and Potts, 2012). All the same, with some exceptions (Yoo 2010; Nafus and Sherman, 2014) in ethnographic research, there are little evidence of research that explores the impact the role of 'smart things' and their relations to 'entities' in the emerging field.

2.2.3. The Production of Space and Social Practice

> The social and the spatial are inseparable and the spatial form of the social has causal effectivity (Massey, 1992:71)

In framing the study of contemporary practice in the field of the IoT and, in particular, in its formative years of 2011 to 2013, it is worth considering spatial and social frameworks that can help not only think of the IoT as an extension of current network paradigm but also locate the practice of the early IoT developers in a broader context of socio-spatial relations. As it was noted already, the spatial aspects

just f*****g do it' McCahill (2015).

65 The IoT is developed across number of fields and industries. In 2015 the top 10 categories of smart things included: smart homes, wearables, smart city, smart grids, industrial internet, healthcare, smart retail, smart supply chain, smart farming (see Lueth, 2015).

are of relevance, both in terms of practice and spatial production as it not only helps to articulate the practice in relation to different spatialities but also uncover how the space of IoT has emerged. The 'space of the IoT' here could be addressed at least in two different terms. As a space of network technologies that further penetrates the relations between physical and virtual world, and as a social space, closely related to the social activities of the advocates of this space and the social conditions within which this space has emerged.

As has been suggested, thinking about spatiality not only facilitates cognition about the functionality of space in a context of everyday actions, but it is also a mode of political thinking (Lefebvre, 1968; Massey, 1992, 1994, 2005; Arendt, 1998; Harvey, 2000; Dikeç, 2012). For example, in his book *The Production of Space* (1991, first published in 1974) Henry Lefebvre argued that in considering creation of any new form, tools or environments that have the capacity to shape the social world, it is necessary to address the everyday practice, social relations and needs of 'social man' (Lefebvre 1995:83,146). As one of the early thinkers in the field of social geography Lefebvre argued that space is not homogenous but rather endlessly created and recreated by different modes of the social and power relations. In building his argument he uncovered three distinct spatial domains in which everyday practice of a social human being is located: representations of space, representational spaces and spatial practice.

The brief outline of these three domains can serve as a starting point from which to consider the spatial, social and power relations in emerging IoT framework. The 'representations of space' is what he calls the dominant space. The spaces of built environments, scientific innovation, infrastructures or a space where the main mode of production takes place, he characterises as “closed, sterilised, emptied out space” (Lefebvre, 1991:165). More recently, this spatial domain has been re-articulated in terms of spaces that have been a “subject of progressive standardisations and coordinations that have taken centuries to put in to place” (Thrift, 2009:97). The second category of ‘representational spaces’, speaks of space that is already produced and directly lived through its associated images and symbols, and a space where people become 'inhabitants' and ‘users'. In his own words: “This is the dominated – and hence passively experienced – space, which the imagination seeks to change and appropriate" (Lefebvre, 1991:39). As such this is also a space inhabited by artists, writers, and "a few philosophers who aspire to do more than describe" (Lefebvre, 1991:42). To articulate this spatial category, he uses metaphors such as "it is alive, it speaks, it embraces the loci of passion" (Lefebvre, 1991:42). The third category he explores is that of 'spatial practice', or a society's space. It is a space of everyday experience in which bodies assert the rhythms of being and interaction. To re-articulate this third category, Nigel Thrift, years later, named it as Place Space. As he puts it: "in everyday life, what is striking is how people are able to use events over which they often have very little control to open up little spaces in which they can assert themselves, however faintly." (Thrift, 2009:103)

While Lefebvre's analysis was situated in the historic context of the 1960s and explored through his observations of city life, its relevance is far reaching. For example, let us consider the space extended by the information network technologies which IoT is said to build upon. Research in the fields of geography, urban and media studies have often revealed similarities between the global vision of the Internet and that of 'old localities' such as a city and its existing networks of streets and utility infrastructures (Graham, 1998; Graham and Marvin, 2002; Souza e Silva and Sutko, 2009). Castells (1996) argued that the global increase in flow and movements has created a new dimension in which the "dominant social processes are reorganised and managed" (Castells, 1996:411). As Stalder (2006) pointed out, Castells' initial analysis made a sharp distinction between the space of flows, "as the space for the elites and socially dominant processes, and the space of places, as the space of isolated and increasingly powerless local populations" (Stalder, 2006:151). Thus, to an extent, Castells initial view of early network space was rather similar to that of Lefebvre's vision of city space, as space colonised by a dominant elite and capital flows[66]. Although, as Stalder showed (unlike Lefebvre, who was forever concerned with the struggle and prospects of counter movements), Castell's initial analysis[67] did not anticipate the power of network self-organisation and the rapid expansion at the edges of

66 The space of flows was first mentioned in Castells' *The Informational City: Information Technology, Economic Restructuring, and the Urban Regional Process* (1989).

67 Though it is fair to say that this vision he later altered in his text 'Grassrooting the space of flows' (1999).

the network, or in other words the everyday practice of people outside the dominant space.

In considering spatial relations in the domain of the IoT, the dominant space, at the time of this study, was marked by overall dominance of the network technologies but also, more specifically, and domain related, by the tracking and identification technologies, or the use of RFID to manage the global flow of things and goods. The RFID technologies were often used in 'intelligent' traffic management and, electronic toll collection in the United States and Asia (Landt, 2005). In the UK, the Oyster card ticketing system used on the London Underground (since 2003) was one of the largest RFID network implementation success stories. Likewise, the RFID applications were also implemented within the retail sector (Konomi, and Roussos, 2006). As explored in the previous sections of this thesis, the dominant space, inhabited by the major technology companies or established research centres was also created via the IoT discourse, in debates about the IoT development as a framework for emergent technologies, a visionary infrastructure and future applications.

Nevertheless, as Lefebvre already stated: “the concept [of dominant space] only attains its full meaning when it is contrasted with the opposite and inseparable concept of appropriation” (Lefebvre, 1991:165)[68]. But, as he pointed out, it is only by means of the critical study of space that the concept of appropriation can be clarified, as it is not always easy to decide in what respect, how, “by whom and for whom they have been appropriated” (Lefebvre, 1991:165). Furthermore, he made a clear distinction between the appropriation and practice of *détournement* or diversion in which an original purpose of space has become susceptible for being diverted or put to a different use, from its initial one. In this process the production of new space emerges (Lefebvre, 1991:167).

Both concepts are relevant in the context of this study. As I have indicated in the introduction of this thesis, and will explore how the Pachube community grew

68 Lefebvre draws on Marx's concept of appropriation that is sharply opposed to that of property (See Marx Capital Vol. 1, page 729-73). Nevertheless, he points out that Marx did not discriminate between appropriation and domination. “For him labour and technology, by dominating material nature, thereby immediately transforms it according to the needs of [social] man” (Lefebvre, 1991:165).

out of a loosely associated group of activists and artists who appropriated the existing technologies, and, I will argue, built 'a new space' where IoT could be re-imagined. However, to analyse this groups relation to a dominant IoT space, their location at the centre or on the edges of the networks (or for that matter their chosen methods for action), I will briefly turn to a few other aspects of spatial discourse that could further facilitate this study.

One such aspect is a changing concept of place/space relations and the consequences it has on how we perceive the space extended by global flows and technological networks. Both Lefebvre and Thrift have argued that practice takes place in a physical place, or what Thrift described as an idea of place "caught up with the idea of a natural register" (Thrift, 2009:102). Early IT analysts argued that place/space today represents an overlap of near and far relations (Giddens, 1990; Therborn, 1998; Held et. al., 1999; Amin, 2002) or a site of intersection between the local and urban influences, culture and flows (Massey, 1991, 1994; Graham and Marvin, 1996). Today, in a context of IoT, some have argued that with IoT's focus on connecting things in a physical world, the meaning of place space is "retuned" again (Coyne, 2010). While the empirical study of this thesis will not directly address the 'retuning' of place/space discussion as such, the thesis will build upon these previous arguments that the notion of place has been changed by the network technologies and address 'retuning' only when relevant.

In the debates around changing meaning of space/place in the 1990s brought forward several distinct ways that could serve us in considering both the spatial practice of Pachube community and what 'retuning' the emerging IoT framework could bring. First, it was argued that the emergence of network space has changed our perception of what constitutes 'place'. In the mid 1990s, researchers across several disciplines engaged in these discussions and some argued that the very idea that 'place' is somewhat more 'real', or that some spaces are more 'human' than others, is changing[69].

69 Thrift (2009) suggested, that such a notion of place is born out of the intellectual certainties of humanism and that in a contemporary setting scholars are moving away from this certainty about what 'human' and 'being' might be. Graham (1998) identified there were three perspectives merging together that explored the nature of information technologies and, subsequently shaped the debate about changing nature of space place. These were perspectives of "substitution and transcendence' (dominated by technological Utopians [he references science fiction writers and early writings in *Wired* magazine in this category]), the 'co-evolution' perspective (drawing from political economy and cultural studies) and the 'recombination' perspective (derived from work in

For example, Batty (1997) while sketching out the preliminary topology of interrelations between virtual cyberspace and physical place[70] argued for the need to redefine reality with its variance: fiction, abstraction and virtuality. This change in perception on what constituted place in the networked realm today might be best illustrated by the latter-day studies in communication science. For example, Healey et al. (2008), motivated by Heidegger's discussion of 'being-with', that defines the interpersonal closeness or distance to that matter, proposed a concept of communication space. While rooting their analysis in a comparative study of community interaction online and offline, they argued that the differences in interpersonal closeness are independent of both space and place and, that variety of communication spaces can be associated with notion of place. As they put it: “technology of virtual spaces is encountered not just as a version of space in the physical world, nor just in terms of place, but also in terms of the type of human encounters that it enables or impedes; the ways in which people can bring each other closer, keep each other at a distance or be there for each other” (Healey et al., 2008). Likewise, they suggested that people need different levels of mutual involvement on different occasions, pointing towards public or private domains of different spaces.

The impact of this re-articulation of the place/space in terms of both physical and virtual realms will be further explored in the study part of this thesis as my observations of Pachube community seemed seamlessly existed in both these realms. However, it would be relevant here to reflect on the broader impact of the way we perceive public and private and how it might also be further altered by this emerging domain. This can already be illustrated by the IoT devices,

actor-network theory)” (Graham, 1998:165).

70 Batty's four categories included: place/space: the original domain of geography abstracting place into space using traditional methods; / cspace: abstractions of space into (computer) space, inside computers and their networks; / cyberspace: new spaces that emerge from cspace through using computers to communicate; and /cyberplace: the impact of the infrastructure of cyberspace on the infrastructure of traditional place. (Batty, 1997). Two of his four domains are particularly relevant in a context of the IoT, but also highlight the stance of two distinct topological forms in which space and place are articulated. The *Cyberspace*, a term borrowed from science fiction writer William Gibson (1984), is where interactivity between remote computers and people take place. Cyberplace, on other hand, is the place of all physical infrastructures such as command and control structures, CCTV in public places, buildings, wires, machines, and cars, or in other words the domain of the IoT. For Batty, as it is for the vision of IoT, the network paradigm takes place anywhere and everywhere. However, such anarchic organisation, in his view, is linked through some common purpose; in particular, Batty embraced the organisational examples such as virtual communities, groups that talk and act across the net, remote processing, communication, decision-making, production processes, urban planning, data access and so forth.

located in the space place, be it in city square, at home or near body proximity and complex questions it raises about what Hanna Arendt once called, the "withering away" of the public and private realms[71]. As several privacy related debates, for example, in the USA have shown, today we can expect no privacy in public spaces, be it physical or digital[72].

Similarly, the private ownership of seemingly public physical spaces is on the rise[73], while the Internet and Web 2.0 platforms in particular, are often perceived to be a public realm, where everything we say is heard by everyone else. Furthermore, the very notion of social in the contemporary context have been re-articulated or as Lovink (2011) puts it "these days the social is a feature. It is no longer a problem [as in nineteenth and twentieth centuries when the Social Problem predominated] or a sector in society provided for deviant, sick and elderly. Now the beast is tamed" (Lovink, 2011:6). The rise of the 'tamed social', was already foreseen by Arendt who characterised it as a "curiously hybrid realm where private interests assume public significance" (Arendt, 1998:61-69). As discussed in previous section, the IoT is built upon this hybrid realm of social platforms and, as such, will bring the attitudes of expedient utility, and of "process" thinking further into our everyday life, thus continue the diminishing of the public and privet realms.

The history of smart meter roll-out can be a good example to illustrate not only this shift towards the merger of private and public realms in a context of IoT, but also another aspect that thinking about space/place brings forward. The development of new technologies, and in particular, new technological infrastructures are not value-neutral and are closely related to geographically located places, hence also to social, economic and political activity and interests (Harvey, 1985; Staple, 1993; Swyngedouw, 1993). For example, Graham (1998) argued that the development of new technological infrastructures is an "asymmetric social struggle to gain and

71 Arendt argued this withering away is a consequence of the expansion of the social. For her, the social was a "curiously hybrid realm where private interests assume public significance" and in such a situation "there can be no true public realm, only private activities displayed in the open" (Arendt, 1998:61-69).

72 For example see Slobogin (2002) on the discussion of public places and the right to anonymity; and Kravets (2010ab) on example cases in a context of electronic surveillance that followed Obamas administration's insistence that people 'should expect no privacy while in public".

73 See Shenker (2017) on The Guardian's investigation of pseudo-public spaces in UK.

maintain social power, the power to control space and social processes over distance" (Graham, 1998:176). In his polemical article on the early rolle-out of smart meters, Graham (1997) argued that the shift to liberalized competition, that accompanied the early roll-out, not only supported the market fragmentation but also created what he called "the urban geographies of network polarization" by "cherry picking" "some affluent consumers" and "socially dumping" "over 4 million poorer UK electricity consumers" (Graham, 1997:141-142). He also, already in 1997, foreseen the emergence of privacy concerns as he wrote: "As energy utilities push "beyond the meter" into the consumer's home, they will be able to assemble much more detailed and precise information, based on actual behaviour rather than surrogate indicates such as bill total and census information" (Graham, 1997:145).

For another ten years, in UK, the smart meter roll-out was rather slow, their implementation was costly for the providers and no much data about energy saving potential was generated. However, things started to change when the notions of climate change, carbon emission reduction and future sustainability models enter the mainstream debate and technological innovation gained political interest. As a report produced by Sustainability First (2006), "aimed to mainstream sustainability into public policy", stated: "prospects of higher energy retail-prices, coupled with the risk of failing to meet UK targets for CO2 reduction in 2010, and new EU-policy developments, have served to re-kindle policy and political interest (in smart metering systems)." (Owen, & Ward, 2006:10). Since then it has become generally assumed that smart metering, by providing more information to consumers, will encourage more efficient use of energy, and offer cost reduction and revenue growth for suppliers.

This shift coupling market liberalization with issues of sustainability, however, lacks support of any studies in the UK. Data on which UK projections of 3 to 10% reduction in consumption and cost are based on a few studies conducted in Norway, EU and USA. Nevertheless, these studies can also serve us to highlight the change in social struggles that have emerged in later stages of the roll-outs[74]. For example, a

74 EU 2020 strategy stipulated that smart meters should be installed in 80%of homes by 2020. The strategy was developed as part of £11bn investment project, which came out of European Union directive 2009/72/EC, "Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC". See also: https://ses.jrc.ec.europa.eu/smart-metering-deployment-european-union.

study conducted in Netherlands (2012) stated: “Despite the many advantages gained by the smart metering system, there is a number of serious issues that may lead to the system’s failure or inability to reach its goals. One such obstacle which can lead to consumers’ rejection of smart meters, is perceived security and privacy violations of consumers’ information” (Alabdulkarim, et. al. 2012:1). This study highlighted the issues related to the 'perceived loss of control' as consumers felt their energy supplies could be regulated without their knowing, 'security and privacy risks' related to data issues and information that could be used by third parties or by unwanted intruders, and finally the emerging awareness of health risks[75]. In 2008 in Netherlands, the roll-out was halted on a basis of a “breach of article 8 –right to respect for private and family life - from the Convention for the Protection of Human Rights and Fundamental Freedoms” (Alabdulkarim, et al. 2012:7). The roll-outs of smart-metering systems are still ongoing, but what 30 years of history has shown us is how the implementation, on an infrastructural level, is achieved under the public framework of common good and sustainability (one, that now merges with the private realm of home, at least in the western world).

Thus, I would argue, the critical evaluation of social, economic and political relations and interests in the domain of IoT have become more burning today than ever. As it is not only the objects of the physical world but also our bodies that will enter the uncertainty of network space further expanded by IoT devices. Thus the questions asked by Lefebvre half a century ago, such as “where, how, by whom, and to what purpose is information stored and processed? How is computer technology deployed and whom does it serve?” (Lefebvre, 1991:86), find the new meaning in the IoT paradigm.

This leads us back to the main point that any new space is socially constructed. What the above example, where the prefix 'smart'[76] somewhat expands the

75 The concern being raised is associated with the radio-frequency radiation associated with the wireless technology (Barringer, 2011). These concerns have led to several resistance campaigns initially in USA such as StopsmartmetersNow.com and later in other countries, for example in Denmark http://www.stopsmartmeter.dk/ and UK http://stopsmartmeters.org.uk/2017/ . In 2017 investigatory award-winning documentary “Take back your power” uncovered the shortfalls in global smart grid programme see: https://www.youtube.com/watch?v=8ZTiT9ZSg3Q see also Bandara and Carpenter (2018) on growing concerns about exposure to anthropogenic electromagnetic fields.

76 On discussion about the rise of 'smart' metaphor see Söderström, et al 2014; and Vanolo, 2014.

meaning of an energy meter, and the larger debates on changing meanings in space/place relations have demonstrated, is how it is the social, economic and political interactions, and language that are actively engaged in production of a new spaces. For example, Batty (1997), in his early relational analysis of four spatial domains in the era of the Internet, pointed out that in the emerging world of 'unthinkable complexity', the overlap of digital and virtual imply, the classifications are intrinsically limited (Batty, 1997:341). These linguistic limits in describing a new phenomenon often has led to already discussed naming efforts, but most often to the use of metaphors that work as ideological constructs in a social production of space[77].

As the previous sections already explored, much of the historical discourse on the IoT is similarly constructed using of metaphors and utopian imaginaries. For example, as noted already, the early implementation of IoT systems, coincided with the emergence of Web 2.0 and the use of platform metaphors. Goriunova in her 2012 book *Art Platforms and Cultural Production on the Internet* criticised this use of the 'web as platform' metaphor as a conglomerate of technical development that flattens the very meaning of the platform concept. In conveying the conceptual origin of a platform Gorunova argued that it belongs to a long history of organisational culture. As she pointed out, in times of political and social unrest, revolutions and avant-gardes, people, in groups, were organising around several guidelines or specific issues, and in such contexts of practice, platforms were understood as open-ended and something that emerge from grass-roots processes[78]. Again, I will test this aspect of space making by the means of language and imagination later in this thesis study, but what these cultural critics already have indicated is that the general space of IoT

77 The linguistic limits in describing this extended space has also been noted by social linguists. The use of water-related metaphors, for example, was discussed by Henry (1993), Vaananen (1993), Palmquist (1996). Jamet (2010) hypothesised that "it is this notion of vastness [of water] which was used to conceptualise the Internet. The sea also represents, at least in the collective unconscious, an almost magical place, a place to be discovered, a place which will keep its mystery, a place which is also potentially full of danger". He also pointed out that metaphors have become lexicalised or, as he put it, they have become *linguistic spare tires* "due to the urgent need to give a name to things that did not exist previously". This not only shows the power of the language in the construction of spatial perceptions but also, vice versa, the power of perception in the construction of language.

78 For Goriunova, the art platforms are the cultural forms of the Internet era combining technology with diverse aesthetic and organisational forms. Discussing examples such as Dorkbot, gatherings of people interested in electricity and all that surround it, she argued that rather than a set of objects, these experiments exhibit a specific kind of cultural practice that is open-ended and emerges from grass-roots processes.

might be both tamed and flattened a prior its physical manifestation.

This brings us to the final aspect of re-articulated realm of space/place and social relations that emerged out of an era the Internet, and the IoT is set to 'retune'. It was French sociologist Bruno Latour, who first suggested that: “The notion of network helps us to lift the tyranny of geographers in defining space and offers us a notion which is neither social nor “real” space, but simply associations” (Latour, 1996:5). What emerged was an Actor Network Theory (ANT) that advocated that the best way to understand the social fabric is through a network-like ontology where all things, humans and non-humans, are interlinked. Nothing means outside of its relations. In these complex network-like relations, the ANT offers a way to think about multiplicity of elements and entities involved, or what in ANT is known as actor or actant. Anything, be it an object, a piece of machinery, a building or city, or for that matter humans themselves – can be an actor who/what is also, always, a network (Law, 1992:384). The impact of ANT is undoubtable as it has gained dominance across the research fields, in the fields of sociology and social science[79], as well as led to emergence of other object-oriented ontologies (Meillassoux, 2008; Harman, 2011).

While we will address the shortfalls of ANT applications later, there is one aspect where the ANT ontology has been particularly beneficial and that is in considering the nature of emerging network objects. Latour's own empirical research in studies of science and technology, led him to rethink the science that for long was universal, and therefore outside space and place, but as something created in a particular place and then transported across the network of other locations and regions. From an object perspective, something created in one laboratory later is reassessed in many others. That something, as he showed, can be a paper on which studies were explained or example of chemical formula or another shape of the piece of knowledge what he termed as 'immutable mobile' (Latour, 1987:227). It is this immutability of something that belongs to network space and it is network space that renders possible the immutable mobility of an object. As Law (2002) later reiterated, “it is that objects are always enacted in a

79 In field of Science and Technology Studies (STS). See: Callon (1986), Latour (1987; 1988; 1993) and Law (1991; 1992).

multi-topological manner, and are dependent for their constancy on the intersection of different spaces. /-/ we find that the immutable mobile achieves its character by virtue of participation in two spaces: it participates in both network and Euclidean space." (Law, 2001:612)

Law based his theory on the empirical analysis, by Marianne de Laet, of the Zimbabwe bush pump. He argued that such objects - that hold their form while shifting their relations - create what he called a 'fluid spatiality'[80]. "Within Euclidean and network space alike, the bush pump is an object that changes shape. It looks different from one village to the next, and it works differently from one setup to the next" (Law, 2001:613). Through described process of breakdown of different parts of the pump and replacements added by the local adopters, Law constructs his evidence of the mutable mobile or what he called the fluid object. The pump is still a pump, or in the words of Law, it "retains its shape as it flows, in different network configurations, into different Euclidean locations" (Law, 2001:614). This example of ANT application and metaphorical language used, illustrates well how the emergence of information networks shaped not only understanding of space/place but also the social theory itself. What he describes is a space of social practice (in Lefebvre's terms) and peculiarities of place/space, as it is by the means of appropriation of the pump and its fluid shaping by local know-how, that its fluidity is permitted.

The widespread use of ANT, in STS and other fields, have shown the benefits of its methodological approach, but criticism does emerge. Although Graham admits: ANT "articulates human-technological recombinations and relationships through a rich, contextual, mapping which avoids essentialising socio technical relations", he also points out that "Its emphasis on socio technical 'hybrids' further underlines the growing difficulties of easily separating something called the 'social' (or, for that matter, the 'spatial') from the 'technological'" (Graham, 1998:180). Thus, ANT use in the entangled world of social relations where human and non-human actors are acting on an equal footing, has been met with

80 In describing the topology of this fluid space, Law writes: "A topology of fluidity resonates with a world in which shape continuity precisely demands gradual change: a world in which invariance is likely to lead to rupture, difference, and distance. In which the attempt to hold relations constant is likely to erode continuity" (Law, 2001:614).

criticism. For example, some have suggested that most research based on ANT remain entirely descriptive and fails to provide explanations for social processes (Amsterdamska, 1990). Others have criticised ANT and its flat ontology[81] that diminishes the role of intentionality and agency in social life (Winner, 1993; Ahearn, 2001; Whittle and Spicer, 2008).

Thus, ANT methodology has not only flattened the space/place relations but also how we study social subjects, practice and relations. In a light of emerging IoT framework, I would argue, there is now a need to 'lift the tyranny' of ANT, renew interest in readdressing this diminishing role of human agency and find the new ways to expand out of the flat network ontology of ANT. Or in other words, in a context of the IoT we must stand up for, what Douglas Rushkoff simply calls - team human (Rushkoff, 2019). One way, as suggested previously, has been opened by the application of phenomenological approaches that addresses the embodied human experience, conceptualised as a crisscross between the body and environments, performative acts or objects. Another approach that might address the matters of 'team' or collective nature of subject better was suggested by Yoo (2010), a researcher in the field of information systems (IS). He expanded on Pickering's (1993) theory of mangle[82], which in its turn, while articulating the mesh of relations between science, technology and society, still emphasises the role of human purpose, goals, and plans. To overcome the post-humanist view presented by ANT, Pickering explores the practice of science through the dialectic of resistance and accommodation or what he called the 'mangle of practice': "I take the mangle to refer not just to this

81 "While Roy Bhaskar (2008) used this term pejoratively to refer to anti-realist philosophies that flatten everything onto an epistemic plane of human access, Manuel DeLanda (2002) reversed it into the positive principle that all realities are equally realities" (in Harman, 2012, para 8).

82 Pickering turn to a temporal character of human intentionality due to encountered resistance 'as a block arising in practice to this or that passage of goal-oriented practice. Thus Pickering's contemplations, while not directly mentioning, also point to phenomenological knowing as he touches upon the notions of intentionality as a most sticky point in ANT ontology. (Pickering 1993:565). "Material agency does not, as it were, force itself upon scientists; there is, to put it another way, no such thing as a perfect tuning of machines dictated by material agency as a thing-in-itself; or, to put it yet another way, scientists never grasp the pure essence of material agency. Instead, material agency emerges by means of an inherently impure dynamics. The resistances that are central to the mangle are always situated within a space of human purposes, goals, and plans." (Pickering 1993: 577). Furthermore, such a proposition, engaged with fundamental aspects of our existence, also reflected Orlikowski and Scott (2008) "socio-materiality" - the inherent inseparability between the technical and the social where entities (whether humans or technologies) have no inherent properties but acquire form, attributes, and capabilities through their interpenetration.

dialectic but to an overall image of practice that encompasses it to the worldview, as an evolving field of human and material agencies reciprocally engaged in the play of resistance and accommodation” (Pickering, 1993:567).

This brings us back to the domain of spatial practice where what counts the most are the actions of human subjects. As Lefebvre warned: “nothing can be taken for granted in space, because what is involved are real or possible acts, and not mental states or more or less well-thought stories. In produced space, acts reproduce meaning” (Lefebvre, 1991:144). In considering the study of early IoT adopters, whose practice from the outset seemed to be inundated with intentionality and desire to empower the citizens of the world, the need to re-address the concept of human purpose, will and action is paramount. As Pickering already suggested “To get to grips with what is special about human agency, then - to break the perfect human/nonhuman symmetry of actor-network semiotics - one needs to think about the intentions, goals, purposes, or whatever of human action” (Pickering, 1993:577).

Thus the last concept to consider here, in the context of empirical study of this thesis', is that of human action. Hanna Arendt, one of the greatest political philosophers of twentieth century saw 'action' not only as the key to the human realisation of freedom but also as the crucial mode of human togetherness. For Arendt, an action is bound to the condition of plurality[83] and human ability to negate the reality of the world, and fully being-in-the-world[84]. Likewise, action manifests human capacity to innovate[85] and alter any situation by engagement in what she called the “web of human relationships” (Arendt, 1998:183). It is worth pointing out that for Arendt, in contrary to a suggestion made by ANT, that every actor is already a network, the 'web' metaphor represented the intangible quality or the 'who' rather

83 As Dikeç (2012) and others have pointed out “Plurality in Arendt is a space-making plurality, understood as a political relation”. Or, in other words, the freedom, plurality and action are what constitutes the politics and she discusses it in spatial terms. However, politics for Arendt does not only equate with political activism or even with civic participation in its narrow sense but rather should be understood in more existential terms (Higgins, 2010). Arendt calls this domain *the space of appearance*, “the space where I appear to others as others appear to me” (Arendt, 1998:198), as it is a “realm of acting and speaking” (Arendt, 2006:220) and a realm which can only manifest as the public realm (Arendt, 1998:220).

84 As d'Entreves put it “that which distinguishes them (humans) from both the life of animals (who are similar to us insofar as they need to labor to sustain and reproduce themselves) and the life of the gods (with whom we share, intermittently, the activity of contemplation)” (d'Entreves, 2016).

85 By exploring the links between true freedom, one's capacity to start something new, Arendt engages with the concept of natality (Arendt, 1998:9).

than 'what' of a human actor (Arendt, 1998:178–9, 184–6, 199–200)[86]. Thus, as many act in accordance of their individual motivations, through the contributions of others, the outcomes result in something different or unpredictable to intentions of any particular actor. By acting together, we can steer action into a certain direction but never know exactly the consequences. Action, like power for that matter[87], as Arendt showed, has this boundless character[88]. This boundless, unpredictable character of action also points to the fact that action is irreversible. Once the process is started it can't be controlled or reversed, due to its entanglement with this web of relations in which every action has some reaction.

Moreover, in the context of this study, it is worth contemplating on Arendt's interpretation of the relation between action and fabrication[89], as it is this context that is of relevance when considering the impact of IoT systems, devices or to that matter any information technologies (Heath and Luff, 2000). It is fair to say that for Arendt, a 'man is never just a fabricator, labourer'[90] or actant, but rather an “acting being, who starts processes where-ever he goes and with whatever he does” (Arendt, 1958:587). Nevertheless, Arendt insisted on a political character of the action and showed how an engineer or fabricator, or in other words, the maker of material things, is not

86 For Arendt, this web of human relationships, in turn, is sustained by communicative interaction (Arendt, 1998:178–9, 184–6, 199–200). In other words, as the action is a space where individuals communicate without the intermediary of things or matter, action entails speech. It is only by means of language we can articulate the meaning of action, or coordinate or steer the action of many agents. Furthermore, as she showed, the speech itself entails action. It is both a form of action and means by which we examine the trustworthiness of the speaker. As d'Entreves (2016) has pointed out “this link between action and speech is central to Arendt's characterisation of power, that potential which springs up between people when they act 'in concert'. Thus, it is only the combination of speech and action that allows us to identify the agency of an agent or, in other words the disclosure of the *who* can be made possible.

87 The power as an effect generated in social relations and unpredictability of what effect our actions have on others, was similarly re-articulated by Foucault: “[Power] is produced from one moment to the next, at every point, or rather in every relation from one point to another. Power is everywhere; not because it embraces everything, but because it comes from everywhere.” (Foucault, 1990:93, first published in English 1978).

88 It appears through the actions and reactions that have no end “the smallest act in the most limited circumstances bears the seed of the same boundlessness, because one deed, and sometimes one word, suffices to change every constellation” (Arendt, 1998:190).

89 Arendt's analysis of historical dimension was grounded on the three fundamental human activities, labour, work and action and their corresponding conditions, Arendt argued that all three should be internally connected and the overplay between all three of them can appear in different contexts.

90 Labour is tied to the primal human condition, the ability to sustain life and ensure the survival of the species. Work is our ability to build and maintain the world around us, things, objects and products or in other words the condition of worldliness or what she calls the objective 'world'. The action is bound to the condition of plurality and human ability to negate the reality of the world and to actualise our capacity for freedom. This has led some to suggest that her *The Human Condition*, the book published in 1958 should be seen “as proposals for a general social ontology” (Walsh, 2011).

autonomous but always stands in relation to political, and suggested that any work or technical innovation should be put under public scrutiny. While the view of science entanglement with social contexts have been broadly discussed (Kuhn, 1970, Latour, 1987, Law, 1991), Arandt's view on “scientific blindness”, “bureaucratic power” or what she most famously described as 'banality of evil', are less actively pursued by contemporary studies[91]. Richard Sennett who was one of Arendt's students, recalls Arendt often thought that fabricators or “people who make things usually don't understand what they are doing” (Sennett, 2008:1).

To counteract this argument, Sennett, took on a quest to untangle the modes of human action to clear the name of fabricators, as not all science is blind, nor all man-made things are evil. He tried to address the changing nature of labour, work and action in the context of technological change. In his book *The Craftsman* (2008) Sennett considered Arendt's distinction between the *Homo faber* and *Animal laborans* and suggested that much of what Arendt assigned as qualities of labour, within a context of 'good craftsmanship' are really the embodiment of work. By comparing the open source Linux developers with public craftsmen of the ancient times, Sennett argued that what drives them both are the same old virtues that values “achievement of quality and doing a good work” (Sennett, 2008:25) for the benefit of all. However, in other examples of contemporary workplace, for example in the story of Toyota plant workers in Japan, he revealed how the ‘hand and head’ remain divided (Sennett, 2008:37).

Nevertheless, Sennett argues that craftsmanship, in whatever form, exhibits the continuum between organic, or the capacity of our body, and the social put in action (Sennett, 2008:290). As Sennett's examples show, there is a difference in the context where action takes place and under what conditions. While most of the Linux developers would associate their contributions with freedom or action and, the open source with the realm of public, the Toyota plant workers were subjects of labour conditions in a privately owned company. Thus what this study and the political character of action suggests is that it is not only the motivations but also the context and conditions of actions that need to be accounted for in study of actions or practice.

91 As of 2017, there are very few studies that address the politics or politics within the emerging IoT framework. Some scholars have looked at the frameworks of Smart City contexts (Greenfield, 2013), some of the use of IoT devices in a context of identity politics (Lukianova and Fell, 2014).

As Thrift points out, the study of practices is a 'practical way of knowing'[92](Thrift, 2000:222).

Furthermore, the acting into the world[93], relates both to humans and technology. This, I would argue, puts further pressure to reassess the impact of our action on the world[94] both in terms of human impact and technologies we create. The world or objective world is here understood as a shared world of material human artefacts, institutions, the man-made things with their qualities of permanence and durability. It is interlinked with the concept of public to ensure the plurality of perspectives, opinions and objective contest that requires a common object of concern. One way to depict this concept is Arendt's example of a table.

> *To live together in the world means essentially that a world of things is between those who have it in common, as a table is located between those who sit around it; the world, like every in-between, relates and separates men at the same time. …. The public realm, as the common world, gathers us together and yet prevents our falling over each other, so to speak. What makes mass society so difficult to bear is not the number of people involved, or at least not primarily, but the fact that the world between them has lost its power to gather them together, to relate them, and to separate them. The weirdness of this situation resembles a spiritualistic seance where a number of people gathered around a table might suddenly, through some magic trick, see the table vanish from their midst, so that two persons sitting opposite each other were no longer separated but also would be entirely unrelated to each other by anything tangible. (Arendt, 1998:52–53)*

92 As Amin points out, "For Thrift this is a line of thinking that incorporates Wittgenstein's desire to grasp the mystery of appearances as they unfold in front of us and in the uses of language; Heidegger's stress on the activation of time and space conjointly through dwelling; Deleuze's wonder at the libidinous, performative, and novelty-generating potentialities of social life notwithstanding the crushing weight of modernity; and de Certeau's and Lefebvre's understandings of place based on the everyday sociology of life." (Amin, 2000:390)

93 For Arendt, the world meant a shared and public world of artefacts, institutions and settings that provide both context for our activities and separate us from nature. For Arendt, it was the discovery of electricity and, most significantly, the launch of an atomic bomb with which we (humans) 'unchain natural processes of our own' (Arendt,1998:148–9).

94 Szerszynski (2003) proposed to rethink Arendt's categories of activity in terms of human performances in relation to nature and technology by suggesting that it is not only through the activity of work that we act into the world but also through the temporalities of labour/life. By example of landscape, or the path that is left by repetitive walking over the time, he argued that "labour is a mode of performance that can leave enduring traces - not in its direct products, which are consumed as fast as they are produced, but in its very iteration and the effects of its iteration" (Szerszynski, 2003:209). He argued, it is "the most fundamental problem of consumer capitalism is not simply that it threatens the 'earth' through resource use, pollution and habitat loss, but that it threatens the 'world', without which there can be no meaning or value." (Szerszynski, 2003:213).

Today, in a context of the Anthropocene (Crutzen and Stoermer, 2000; Borenstein, 2014) and the "end of cheap nature" (Moore, 2015) in which most of the reserves of the earth have been drained, burned, depleted, poisoned, exterminated, and otherwise exhausted, we are forced to "face Gaia" (Latour, 2013). By acting into the natural world, we have altered nature and made it into a part of 'our world'. As already discussed in previous sections, the contemporary visions of IoT are closely related to concepts of climate change, sustainability and environmental monitoring. Thus, I would argue, to change our 'common' perception of what constitutes the objective world and subsequently to make the environmental urgencies into the shared subject or that common table around which we can relate to each other, the IoT becomes the tool for knowing, of measuring, quantifying etc.; or, in other words, the mathematical knowing. But as Arendt already pointed out, by unchaining natural processes of unpredictable nature and "instead of carefully surrounding the human artifice with defences against nature's elemental forces, keeping them as far as possible outside the man-made world" as we did it in the past, today, "we have channelled these forces . . . into the world itself" (Arendt, 1998:148–9).

What does the unpredictability of natural forces brings to the way we create knowledge, reason and act into the world? Can the study of early IoT adaptors help us further understand these processes? How space and boundaries are negotiated? By whom and to what ends the technology is put into place? Can then the analysis of action, both in terms of the words and deeds of early IoT adopters help us understand the conditions of practice while reinstate the intentionality of human actors?

2.4. Conclusion

In considering the context for the empirical study, this theoretical part of the thesis mapped out the history of IoT and theoretical frameworks in which this thesis was conceived. First, by reflecting upon the history of IoT-related technologies, their development and contexts this chapter showed how the IoT discourse emerged out of several IoT-related technology research fields. This chapter argued that the current framework of IoT is mostly driven by the technological discourse, or, in other words determined by the technological conceptions and, prevailing vision of thing identification, management, automation and data gathering, predominantly in corporate frameworks. The study of IoT-related literature and research papers also highlighted the frequent use of future-based visionary language in describing the possible benefits and promises the implementation of IoT systems could bring about. These were mostly associated with a better global resource management, environmental sustainability and energy and financial savings.

The development and deployment of such all-encompassing vision of 'anything, anywhere, anytime' connectivity, however, foments countless challenges, both on technological and social levels. The technological challenges are not only associated with the technological complexity and integration of diverse number of technological layers involved, in terms of hardware, software, semantic structures and middleware, but also on a system level and overall interoperability of currently fragmented systems. A variety of non-technical challenges concerning social, legal and ethical issues such as implementation, trust and privacy, for example, are also extended to issues related to the research field itself and recognition for research to be conducted across several different fields of knowledge production.

The complexity of IoT domain is further stirred by the intrinsic fuzziness rooted in the very name of the IoT phenomena and, as the second part of this chapter argued, the two contrasting perspectives in which the development of the IoT is fostered. From the network perspective, the IoT is viewed as an extension of the Internet, thus on both, the technological and social level will most likely inherit the Internet's technological pedigrees, complexity, offerings and limitations. To emphasise the context of this thesis' empirical study, the emerging role of platforms and their role in network structures, was highlighted. While the adaptation of such Web 2.0 technologies like APIs, shields and stacks in IoT context allow different platforms to evolve independently, their centralised approach is often considered to be limiting from the thing or device perspective primarily due to unilateral mode of communications.

The context of things, as this chapter argued, acts as a critique of global network imagery, as it brings further heterogeneity and condition of unpredictability to the IoT domain. This, first, is related to the ambiguity of the word *the thing* itself, and second, to the physical world or context in which a thing is located. As it was explored, the word *thing* can not only signify an object but can also relate to performative acts or events. Thus, just like the properties of the physical world the thing implies temporality, distance, change and a presence of perceiving subject. Furthermore, the thing in the IoT context most likely relates to two distinct entities – a thing that is measured and a device that performs the measurement.

As the IoT is set to further objectify what, so far, was only perceivable (or in other words: the perceptual aspects of world out there) as the chapter argued, this requires the intervention and phenomenological investigation that goes beyond this thesis framework. However, to contribute to this suggested path, the chapter addressed the history of the thing perspective by investigating work of artists and writers. The creative works of art and literature, best illustrate the intersubjective perspectives of this emerging field. While both the works of art and writings are intersubjective intentional objects, the work of art can transcendent the formal, material and existential aspects of an idea, while the language or sentence-forming activities of writers helps us to articulate unthinkable in words. For example, as it was explored, the one of the most contentious aspects from the perspective of thing development is the question of how much autonomy and agency *the thing* in the IoT domain has, or might have, in the future, or how the agency of a device would alter the relations between humans, humans and non-humans. This question of autonomously acting devices was early on explored by the work of Usman Haque's *Evolving Sonic Environment III* (2005). The works underlying system, EnvironmentXML was a precursor for what later became the Pachube, the IoT platform explored in this thesis' empirical part. The precedent of this work and its relations to the Pachube platform is a valuable indicator from which the conditions of contemporary practice can be evaluated.

In recognising the properties of the physical world such as distance, materiality and local characteristics of space and contexts, the third part of this chapter turned to consider the social and spatial frameworks in which not only the contemporary developments in a domain of the IoT could be considered theoretically, but also that could assist in articulation of the practice of those at the forefront of these developments. The early observations of Pachube community and emergence of Pachube platform was situated at the time of inexplicable fragmentation (described in the first part of this chapter). The materiality of IoT or the presence of IoT systems were barely noticeable, while IoT discourse, scattered around diverse research fields, were conducted under heterogeneous names of the phenomena. The intensity with which the Pachube community embarked on embracing and propagating the concept of the IoT led me to consider the frameworks of spatial practise and social production of space.

This part of the chapter addressed the space of the IoT from two perspectives. As already discussed, the IoT is an extension that is built upon the infrastructures of the Internet, or, in other words: space already extended by the network technologies. The second viewpoint on IoT space is that it is socially produced by the actions and discourse in this domain. To further interrogate these perspectives, the chapter turned to the thinkers in the field of social geography and critical social and media theory that can serve as a solid ground from which the emergence of IoT space could be articulated. For example, Lefebvre's analysis of spatial relations and processes of spatial production provided a great starting point for identifying the three spatial domains and social power relations in each of them. The relevance of concepts such as representational space and spatial practice in domains of place/space, were highlighted. As explored, the recent history of changes brought about the era of the Internet testify not only the altered ways we think about place/space relations but also how we approach the study of the human subjects and agency within this now extended space of networks. To consider this past was an important point from which to contemplate the future 'retuning' the emerging IoT framework could bring.

It was identified that there are several aspects relevant to the empirical study of this thesis. The changing perceptions about the meaning of place, political and economic relations in place/space contexts, the role of language and discourse in the social construction of space and finally the issues related to Actor-Network Theory and its methodological approach in which analysis of human and non-human entities is conducted in a similar manner. All these aspects, in one form or another, suggest the return to a centrality of a questions related to a perception of human subjects. For example, as studies have shown, the changing perceptions about place/space, is driven by the feeling of 'being-with' someone, and that is what defines the interpersonal closeness or the perception of distance in a virtual realm. The example of the smart meter roll-out, and its history, demonstrates the power of political and economic forces in the shifting perceptions about importance of one or other factor. The use of language and the use of metaphors similarly reveals how the new ideas and subjects acquire their space where to prosper by bending our perceptions of systems or ideas that are often invisible to human eye.

The emergence of IoT, and the shifts it will bring, is so far described either as a 'retuning' (Coyne, 2010) of these place/space aspects or as a total paradigm shift (Riffkin, 2014). At this point in time it is still hard to foresee the total impact the implementation of IoT visions will have; however, some 'retuning' can already be articulated, if only theoretically. For example, projects like The Good Night Lamp[95], that shares one's presence and availability with global friends and family, offers experiential and situated feelings of 'being-with' over distance and in real-time. However, the presence of the data generated suggests further 'withering away' of private and public spheres. Similarly, the political and social advance of Smart Meters has been met with growing concerns over matters of security, privacy and public health. In the realm of social theory, as this chapter argued, there is a grater need to overcome the flat ontology of ANT, or, to put it differently: the looming emergence of active things and their agency within the IoT domain requires the reconsideration of accurate perspective to feeling, thinking and acting human being.

There were several approaches and methods considered in relation this latter concern. Phenomenological methods and consideration of embodied experiences, could be one way to address the human agency. The theory of mangle, in which relational studies of entanglements emphasise the role of human purpose, goals, and plans engaged in the play of resistance and accommodation, and studies of human actions could, likewise, help to re-articulate the relations between humans and things in the IoT domain. To consider these, the chapter, finally turned to address concepts relevant to the study of practice and action. The focus

95 See: http://goodnightlamp.com/

on action brings forward several relevant conditions and socio-spatial aspects. For example, the need to articulate the boundaries and divisions between states of human conditions such as work, labour and action; the need for plurality and public space to support the political character of action and in addressing the need for accountability; its relation to innovation and, finally, the human need to act together, or, in words of Hanna Arendt, in the “web of human relationships”.

Thus, to situate this thesis' empirical study, this chapter mapped out the spatial and social aspects and theoretical frameworks relevant to study of spatial and social practice in a domain of the IoT. As the next chapters will explore, the practice of the early developers of Open IoT (same as the practice of Linux developers who associated their contributions to Linux platform development with ideas and contexts of freedom and public domain) suggest correspondent frameworks at work. Likewise, their insistence on acting together in a framework of community and acting in and for the public domains has a significance here. Furthermore, as the IoT further facilitates the acting into the world, in which the environmental urgencies become the shared subject, or a common table around which we can relate to each other, the study of practice would also need to consider the study of methods used in creating the practical knowledge of 'the thing' out there we aim to know.

3

THE CASE STUDY:
COMMUNITY, LANGUAGE AND PRACTISE

3.1. Introduction

The first part of this thesis suggested that the emergence of a current IoT framework, in terms of IoT discourse and socio-technological developments, is an issue that deserves investigation across several fields of research. This study will offer an insight into a particular time in IoT history, as well as a glimpse of the language and practices of early IoT advocates, thus contributing to the history of IoT and to the social sciences. As we have seen, at the start of the second decade of the 21st century, research into IoT-related technologies was scattered across academic, business and technology research networks. However, almost twenty years of network technologies and the proliferation of technological know-how had also fostered the emergence of a collaborative technoculture at the edges of these established networks. To explore the contributions made by these practises is relevant to our understand of the complex world we inhabit today. Yet, that requires an interdisciplinary approach and thinking across disciplinary boundaries. For this study of practice and language, it has meant engagement with the fields of cultural theory, ethnography, linguistics, as well the studies of technology and computer science.

The empirical study engages with the community that emerged around one of the first IoT platforms: Pachube[96]. Besides highlighting the fact that the first IoT platform emerged out of the technologies developed within the frameworks of art

96 Pachube was named as a leading company in IoT in a ReadWriteWeb list of the five biggest Web trends of 2009. See article here: http://readwrite.com/2009/12/30/top_5_web_trends_of_2009_internet_of_things_1/

and interaction design, this qualitative case study examines how a group of geographically dispersed people created an activity, and set in motion, the development that not only promoted the concept of the Internet of Things (IoT), rather than ubiquitous computing for example, but also collectively created examples of tangible applications. How, by the use of Web 2.0. platforms and other online and offline spaces, they managed and disseminated the processes of knowledge creation and product production, and with that, I will argue, produced the space where the Open IoT discourse emerged.

As noted already, the study addresses a particular time, 2011 to 2013, which was a trigger stage of the IoT developments; I use this term following Perez (2002), who defined the trigger stage in the innovation cycle as the time and space when the so-called early adopters are involved in building and testing new ideas, products and applications. Thus, by researching one such group and the contemporary relevance of their imagination, this study hopes to uncover not only the rhythm and the direction of the IoT development, but also assess the role played by what Kelty (2008), in the context of the Internet and, in particular, the free software culture, called 'the recursive public'. Kelty, in his book *Two Bits* (2008), described a recursive public as "a public that is vitally concerned with the material and practical maintenance and modification of the technical, legal, practical, and conceptual means of its own existence as a public; it is a collective independent of other forms of constituted power and is capable of speaking to existing forms of power through the production of actually existing alternatives" (Kelty, 2008:28). Kelty argued that Free Software is all about making things public, and those involved with it are not united under one particular ideal or group identity, but rather governed by what he called the geeks' imagination of the technical and moral order. "It is a practice of working through the promises of equality, fairness, justice, reason, and argument in a domain of technically complex software and networks" (Kelty, 2008: XI). The Pachube community, without doubt, fell into this articulation as they not only relied heavily on the use of open source[97] but, most notably, as it will be explained, promoted and

97 While Free Software emerged as a cultural phenomenon in the late 1990s, its history is at least two decades older. The dot.com boom and crash brought in divisions in the minds of the Free Software advocates and subsequent re-framing of the practices as Open Source. In the early 2000s, Tim O'Reilly argued that the biggest change that had happened "since the introduction of the standardised architecture of the IBM personal computer in 1981" (O'Reilly, 2004:para 3) was the rise of Open Source, or what he called the Open Source (OS) paradigm shift. O'Reilly introduced

fostered the public aspects of the Internet of Things and worked towards production of actual alternatives.

Yet, before we apply any methods of analysis or framing to this community, let us return to the formulation of this case study. Stake (2008) distinguishes three types of case study: intrinsic, instrumental and multiple instrumental case studies. This study could be defined as intrinsic as it provides a rich insight into a historically-located phenomenon: the workings and processes of one group. However, as their actions were motivated by larger socio-techno-political developments of the Internet of Things, citizen science, and collaborative commons[98], the study is also an instrument to facilitate our understanding of the emerging IoT phenomenon. The study is composed of three separate parts, each addressing different issues and discoveries. Thus, it is an instrumental case study that aims to address questions such as: how is the space of the IoT constructed and negotiated? By what means and by whom? What does the practice of this community tell us about changing relations in production processes, collaborative culture and the IoT?

3.2. The Community

From the outset of this study, I chose to address this group in terms of community, and more precisely as a 'community of practice' (CoP) (Lave and Wenger, 1991; Wenger, 1998; Wenger, McDermott and Snyder, 2002; O'Connor, 2003; Cox, 2005). I will adopt the Wengers' definition of CoP which he describes in following: "Communities of practice are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly" (Wenger, 2006:3) and "Communities of practice develop around things that matter to people. As a result, their practices reflect the members' own understanding of what is important" (Wenger, 1998:2). In his early work, Wenger (1998) identified three main

the 'three Cs' - commoditisation, collaboration and customisability - of OS as long lasting trends that would shape all around it. See also: Raymond (1999).

98 Here I use the term to refer to both the concept of commons-based peer production, in which the value is created by productive publics that are motivated by collaborative interests, and the vision (promoted by Rifkin, *2014:18-19*) of commons as a disruptive force for existing relations of production. ("*At a certain stage of their development, the material forces of production in society come in conflict with the existing relations of production,"*Marx, 1977:4)

characteristics that define a community of practice: domain, community and practice. These three characteristics provided the initial framework and starting points from which to address the collective formation of this community. However, it is important to note that it is often the analysts who use such concepts rather than the participants themselves. Likewise, there is a certain fluidity of where the borderlines of such communities are, or how individual participants negotiate their identities within such contexts. While the first part of this study, in particular, will address this fluidity by searching for the border markers and frameworks employed in participants' speech, it is worth highlighting that in the case of the Pachube community, it was often the participants themselves who insisted on the use of the term *community*.

Wenger's markers on what characterised the Community of Practice (CoP) can also help us to map out core characteristics of the Pachube community. First, let us address the domain. While broadly speaking, it would be the Internet of Things, participants may also identify with other domains, such as open software and hardware movements, or 'makers' culture and, most notably, the domains of public and citizen science. It is also worth pointing out that some of these associations with one or other domains highlighted not only their previous work, but also reflected the interests of their geographically located peer group. For example, developers from New York had a strong association with the local sensemakers group, whose focus was to develop citizen-orientated tools. The two NY developers who led the AQE device development, both in their mid-twenties, were graduates from Parsons School of Design (NY). Leif Percifield previously developed project DontFlush.me[99], an Internet-based alert system to allow NYC residents to help reduce the amount of discharge of raw sewage into NYC's waterways. Joe Saavedra[100], on the other hand, during his master’s degree at Parsons, developed the project CitizenSensor, an open-source, wearable pollution monitoring and data collection system, and subsequently took a lead on Air Quality Egg hardware development.

As noted, many of the members were early adopters of EnvironmentXML, or what

99 See more on the project developed by Leif Percifield here: https://www.ioby.org/project/dontflushme and https://www.mnn.com/green-tech/research-innovations/blogs/dontflushme-a-nyc-sewage-level-alert-system

100 See more on Joe's work here: http://jos.ph/

became Pachube, before it became a commercial entity; thus, they had some personal ties with its key developers. The leadership of Usman Haque undoubtedly played a role as many of those who attended the early IoT meetups were artists and researchers in the fields of digital media, design and architecture. However, it was their interest in domains of the IoT, networked environments and public engagements that created the commonality of their practices. In NY, artists like Mark Shepard who, at the time, was developing *The Sentient City Survival Kit* project[101], the already-mentioned Natalie Jeremijenko (see Chapter 2.2.2), and participants from the Public Laboratory[102], joined the community meetups and ran workshops there. Similarly, in London, the community had a mixed constituency. Many of the UK participants were involved in home monitoring systems, the very first larger group adopting a use of the Pachube platform. For example, one of the most vociferous supporters in the London group was the freelance consultant Paul Tanner, in his sixties, who runs Virtual Technologies UK, a consultancy network of IT specialists. Another was Andrew Lindsay, an IoT consultant in his forties, who is also a co-founder of the award-winning Oxford Flood Network team. There were also a notable number of creative individuals, like designers Alexandra Deschamps and Ben Redford, both in their early thirties, and the already-mentioned Christian Nold (see Chapter 2.2.2.), who took an active part in the community's organised events.

Thus, it is this link between the open source movements, media culture, DIY, and the citizen science orientation that aims to address global challenges and environmental threats that best articulates the domain this community embraced. The sense of community, Wenger argued, could be best recognised if the issues of value and community as a productive force are foregrounded. Wenger et al. (2002) articulated this in the following:

> *“They may create tools, standards, generic designs, manuals, and other documents - or they may simply develop a tacit understanding that they share. However, they accumulate knowledge, they become informally bound by the value that they find in learning together. This value is not merely instrumental*

101 See more on the project he developed during his Eyebeam Art and Technology Residency here: http://www.andinc.org/v4/sentient-city-survival-kit/

102 A non-profit collective that addresses environmental issues by the use of creative and DIY means. See more on Public Lab here https://www.publiclab.org/about

for their work. It also accrues in the personal satisfaction of knowing colleagues who understand each other's perspectives and of belonging to an interesting group of people. Over time, they develop a unique perspective on their topic as well as a body of common knowledge, practices, and approaches" (Wenger, McDermott and Snyder, 2002:5).

While one of the key goals of this study is to explore this community's shared values and what it is they produced, from the outset it was apparent that their involvement with the IoT extended beyond the purely technical domain. Furthermore, as the study will also explore, the contributions they made (or, in other words, the community's productive force) were most notably created in discussions on mailing lists, forums, and across several social platforms.

The other aspect of this community that needs to be highlighted is one rooted in a rich history of social movements in which community organising is a proactive act, getting people to work together for systemic social change. It is a tactical approach, a community-building practice in which the community serves as the arena in which strategies and tactics are identified in order to achieve direct representation so as to influence government policies, corporations and institutions (Rothman, et al., 2001). With the rise of online communities and Web 2.0 social platforms, not only have community organisers[103] become a professional class, but also their engagement strategies and principles of organising are often transmuted through social media strategies. This aspect of a community is best illustrated by the role of Ed Borden, as Pachube community organiser.[104] Ed joined Pachube before it was acquired in 2011, but became a part of the acquisition, and subsequently led the community engagements observed in this study until March 2013.

Nevertheless, it is the third character of Wenger's conception of a community of practice that is of most interest for this study as it places practice at the centre of the

103See more on the role and tactics of community organiser in Beckwith and Lopez (1997).

104In an interview I conducted in March 2015, Ed recalled his early involvement as follows: "After we were acquired my job title was … no I think, I didn't really have a job title. But I think I called myself the Platform Evangelist. I generally had it very flexible and I could basically put money where I wanted. I paid for people to move around. I mean, I sponsored quite a bit of travel. I wanted to have meetups … kind of intermingling a little bit." As he recalls "the marketing budget probably was in the realm of $150 000".

enquiry. The participants are also practitioners who share experiences, tools and resources. The key would be that the participants were also the users of the Pachube platform - the shared resource. Although, they were also makers and designers of other early examples of connected devices developed in other contexts. However, this study in particular will address their collective practice in producing the air quality measuring device, its network, and subsequently the space for the Open IoT to emerge.

While Wenger's categorisations are good starting points from which to address the practice of the Pachube community, it is also worth pointing out the broader cultural shift that has taken place over the last few decades. The early work on communities of practice were mostly conducted in contexts of situated learning and knowledge production (Lave, 1988; Lave and Wenger, 1991), while the later studies (Wenger, McDermott and Snyder, 2002) have shifted to questions of value creation in a context of managerial studies. “Companies at the forefront of the knowledge economy are succeeding on the basis of communities of practice, whatever they call them”[105] (Wenger et al., 2002:3). This has led the critics of CoPs to argue that this decisive shift has led to a commodification of the idea of community of practice (Cox, 2005), and its instrumentation (Vann and Bowker, 2001). As Cox (2005) pointed out, it is the ambiguity of terms 'community' and 'practice' that are a source of the concept’s reusability that allow it to be re-appropriated for different purposes across the different fields.

While the relationships in every appropriation offer rich grounds for studies, scholars have argued that there is a shift in the relationships of production, expressed by the emergence of the peer production phenomenon that has led to the rise of knowledge, sharing and collaborative economies (Benkler, 2006; Bauwens, 2012; Green, 2012; Aigrain, 2014; Sundararajan, 2017). Bauwens (2012), in his detailed study of the collaborative economy, suggested that the spread of network technologies and the

105“Yet organizing systematically to leverage knowledge remains a challenge. Leading companies have discovered that technology is not enough, and that cultivating communities of practice is the keystone of an effective knowledge strategy. Communities of practice come together around common interests and expertise - whether they consist of first-line managers or customer service representatives, neurosurgeons or software programmers, city managers or home-improvement amateurs. They create, share, and apply knowledge within and across the boundaries of teams, business units, and even entire companies - providing a concrete path toward creating a true knowledge organization.” (Wenger et al., 2002:6) push for interactivity have placed collaboration and community engagement at the centre of contemporary business practice. His analysis indicated that this relates to a genuine example of community-centric peer production, which he divided into three distinct typologies: peer-directed collaborative production, mixed collaborative production, and for-profit collaborative production. Nevertheless, as he points out, in practice, the majority of collaborative projects today are led by rigid organisations controlled by corporate players. They operate within a dual logic, and benefit from associating social and market capital combinatory approaches. An overemphasis of the sphere of the commons may lead to underfunding and precarity in the community of contributors, while an overemphasis on market dynamics may lead to the 'crowding out' of social contributions. This, as he suggests in accord with other critics of CoP appropriation, comes at the 'price of community' (Bauwens, 2012:35).

This shift and 'whatever' marker could also be applied in the context of the community at the centre of this study as, during my observations, its formation underwent a number of transformations. What initially was a loose group of people with similar interests turned into a community, and later became a network and asset for a start-up to be incorporated. This shift in its formation was also acknowledged by Ed Borden in an interview years later: "engagement was quite a big buzzword at that point. I wanted to focus on geographic place and started picking New York and Amsterdam to start [IoT meetups] because they were … already connected. Our community was already there, working together, doing things, talking". Despite these shifts and the demise of Pachube, the community is still there. The group continues to engage with like-minded people who share values of openness, fairness and justice in the IoT domain[106]. Thus, I would argue, the formation of what I refer to here as the Pachube community could likewise be treated as what Stewart (1996) termed 'shadowy groups called communities of practice' or, in other words, a formation of groups that are hard to control, "but easy to kill if instrumentalisation of them is suggested, as no one owns them and they are responsible only to themselves" (Stewart, 1996:173-5).

As noted, there is always some fluidity at work in terms of the identity of an individual or in naming a communal formation, thus there are further concepts

106See proliferation of Open IoT frameworks, for example.

relevant here. While the focus of this study will be to explore the practice of this community, the study will also investigate those who gathered at the Pachube community-organised IoT meetups, or later joined the AQE network, and in turn could be identified as a ‘community of interest’ (Brown and Duguid, 1991; Uimonen, 2000). Likewise, Wellman's (1999; 2002) concept of the 'networked individual' or connected individuals is of relevance here, and in particular in the context of the extended AQE network of IoT meetups. While the qualities of the 'networked individual', with its weak ties to others or as one who possesses a strong mark of individuality and rationalism, are the attributes of all subjects in the information society, in the context of this study, it is their ability to act together that is of more interest here.

Furthermore, when contextualised in a previously discussed framework of Arendt's HC (see Chapter 2.2.3), the everyday practice of this community could be aligned with Senett's analysis of open source developers, that situates them within a work/action rather than a labour/work dichotomy as their contributions were aimed at benefitting the public field rather than the market economy or organisational capital. Likewise, I would like to argue with Light and Miskelly (2015) who, in their comprehensive analysis of the differences between the concepts of the sharing economy and sharing culture, argued that there “is no sharing economy, but a variety of new cultures being fostered” (Light and Miskelly, 2015:49). It is this culture of collaboration in a shared community setting that will be mostly explored in this study.

3.3. On Methodology

In considering the methodological approaches to this study, it became apparent that not only the subject I wanted to study but also the distribution of the number of elements involved required a common framework. Marcus and Fischer (1986), reflecting on neo-Marxist movements, examined how larger systems were registered and materialised at the local level. They argued that changes in the structures and interconnections of late capitalism had increased the scale and complexity of social processes, thus demanding new methods for analysis. Jenna Burrell (2009) in her paper *The Field Site as a Network: A Strategy for Locating Ethnographic Research* takes this argument further by reconfiguring the field site that traditionally would be a location or a particular organisation into a network of sites. Burrell argues that the field site as a network is a continuation of what George Marcus (1998a:79) identified as "multisited" ethnographies. Burrell argues:

> *To reconcile these spatial complexities, I conceived of my field site as a network composed of fixed and moving points including spaces, people, and objects. /-/ Therefore, networks provide a way for developing an unconventional understanding of social processes. It is a structure that can be constructed from the observable connections performed by participants. (Burrell, 2009:189)*

To support her theory, Burrell offered tips for networked field site construction, with the following three being the most relevant to this study: 1) seek entry points rather than sites; 2) consider multiple types of networks; 3) know when and where to stop. Thus, the field as a network approach and her offered tips became the starting points for my study. Choosing the field site as a network approach not only helps to overcome the nature of territorial field sites, but also it can offer richer contextual detail (Howard, 2002). The network nature of the dispersed community of practice; the individuals; the online and offline spaces inhabited by the community; objects, but also the things, and in particular here will be the air quality; as well as their relationship to the changing tools of production and market structures of capitalism together form the total field site of this study. Furthermore, each of these elements offers an entry point for analysis of specific issues, while the network field site sustains engagement with the broader research topic. For example, as the study will explore, the Pachube community engaged and appropriated both the existing online platforms as well as offline spaces for advancing their cause. Some of these were what we could identify as public spaces, such as museums and media art spaces, while others were privately owned social platforms, such as Meetup, Kickstarter and Pachube. A closer look at each of these could not only provide us with some insight into their specific attributes, but also help us to understand the broader questions related to contemporary practices.

Furthermore, this study hopes to create a more holistic view and uncover the intersubjective understanding of the spatial and social practice of this community and its relation to the IoT, rather than engage with a formal understanding of the relationship between structure and actions. Thus, by focusing attention on one particular group of builders and their perceptions of the IoT space, this study searches for the properties of this space, as it is this space that "allows them to build and imagine it" (Kelty, 2008:29). Kelty, as other researchers in the fields of social and technology studies, as well as anthropology, has applied a combined method of ethnography and discourse analysis in order to advance the understanding of, what Coleman (2010) elsewhere has called – 'vernacular cultures'[107].

A multi-entry context, and the nature of this community, meant that to uncover specificities, or different perspectives, requires the adaptation of several methods, both in terms of data collection and analysis. A growing number of researchers concerned with accessing the complex interconnections of the social and technological have argued for a combined-methods approach because of the distributed nature of these phenomena, which often extends beyond a particular locale and across the borders of the physical and the virtual (Kelty, 2008; Hine, 2000; Howard, 2002; Coleman, 2010). While such an approach promotes a combination of both qualitative and quantitative methods to enable a deeper investigation of our subject, the multimethod strategy (Brewer and Hunter, 1989) is of relevance here:

> *The multimethod approach is a strategy for overcoming each method's weaknesses and limitations by deliberately combining different types of methods within the same investigation. (Brewer and Hunter, 1989:209)*

In this research, I have combined tools and elements used in classical ethnography, with an emphasis on aspects of lived experience and the physical world (Agar, 1982; Rampton et al., 2004); action research, with its strength in generating access and solutions (Light and Miskelly, 2008; Mcniff and Whitehead, 2011; Reason and Brandbury, 2013); virtual ethnography, exploring online experiences (Hine, 2000, Wittel, 2000); and linguistic ethnography, which is more suited to accessing the "tensions between what is felt or meant and what is most readily sayable" (Rampton, 2004:7; Duranti, 2010). The largest part of any ethnographic study is conducted as

107Coleman (2010) followed the digital genres and groups such as hackers, bloggers and migrant programmers.

participant observation (Geertz, 1973; Silverstone et al.,1991; Delamont, 2004; Hoey, 2008; O'Reilly, 2009). However, I have also appropriated other methods, such as interviews, video or photographic work, use of statistics, and archive work (Silverman, 1993, cited in Holstein and Gubrium, 1995; Crang and Cook, 2007; Forsey, 2010). In the following subsections, I will address the specific elements of three ethnographic approaches that I would like to highlight as they indicate a more nuanced approach than assumed.

3.3.1. Ethnographic Action Research – Participation and Access

As I began this inquiry into the emerging phenomenon of the IoT, I was passionate about the new opportunities opened up by this technological paradigm, both in terms of technology and its sociality. As a practitioner, to an extent, I was one of those nodes in that network of people that, now, as a researcher, I will call a community of practice. By entering the network, the position of the researcher is unavoidably an active one (Tacchi et al., 2003). By accepting such a line of reasoning, it could be said that the largest part of this ethnographic study, in particular in terms of data gathering, was conducted as ethnographic action research. For two years (2011-2013) as a researcher, I closely followed this group of developers, attended and participated in their gatherings on semi-public and public occasions, followed their discussions on their mailing lists and conducted numerous interviews with its members. In parallel, I also conducted my own research. I directed several practical research experiments on connected devices[108], their data, and their physical interfaces[109]. However, it was the recorded observations on video, in photographs and audio recordings, as well as collected screenshots, data records, personal notes, and a significant amount of gathered media articles on the broader IoT discourse that became the focus of this research study.

Many of my encounters with the community members have been in person and ad-hoc, while others were pre-arranged. While this self-proclaimed community is

108I joined AQE device building and data upload workshops during which I constructed my AQE device prototype. Later, I also acquired one of the AQE V.1. devices and monitored data outside my home in East London.

109See project The Breather documentation here: https://spacebreather.wordpress.com/ and video here https://vimeo.com/100812225 situated in different cities of the world, the physical meetings I attended were held in London[110]. At the first London IoT meetup I attended, I asked for permission to video the event for my research. However, it soon (Dec 2011) became apparent that the organisers were interested in using my video recordings as the IoT meetup documentation and for event promotion. By agreeing to this, I became even more immersed in the process of this community-making. I video recorded the IoT events (see full list in Appendix I) in London during the period January to June 2012, during which I also conducted interviews with the key developers (see full list in Appendix II). With my background of artist/filmmaker, I was also asked to edit video material from New York and Amsterdam meetups. Through this editing opportunity, I gained an insight into the activities and workings of the IoT communities in these cities. As a result, I not only acquired a rich and substantial amount of ethnographic data for my research, but also produced three meetup documentaries[111] and one larger documentary that was later published on the Internet[112], and linked to the community blogs[113]. My contributions to the cause of this community, in return for my use of the recordings for this study, formed the basis of our mutual exchange.

By contributing to the community in such a way, and by appropriating the tools of ethnographic action research (Tacchi et al., 2003), I simultaneously became a committed participant and an observer. As Light and Miskelly (2008) have argued, the 'activist' type of commitment is a “necessary part of gaining admittance into the particular world that we wished to study, both ethically and pragmatically”. As they explain further: “When looking at a process which is by definition open-ended and unpredictable, researcher methods must assist in revealing the process rather than imposing a rigid structure” (Light and Miskelly, 2008:423/5).

The open-ended nature of the Pachube community (which I joined in Nov 2011) meant that it was up to me to decide when to stop the data collection for the purpose

110The format of the meetings was often defined by a framework of the online social networking platform Meetup.com that facilitates offline group meetings in various localities around the world.

111See Jan 2012 London meetup documentation here: https://vimeo.com/40019578 / and New York meetup here: https://vimeo.com/36209946 / See March 2013 London meetup documentation here: https://vimeo.com/40471645

112See full documentary recorded at The 2nd Citizen Cyberscience Summit Feb 16-18, 2012 online here: https://www.youtube.com/watch?v=jU2uPky-eko

113See documentary on AQE Kickstarter blog here: https://www.kickstarter.com/projects/edborden/air-quality-egg of this study. Subsequently, I stopped video recording observations after the June 2012 Open IoT Assembly. I continued to attend the IoT meetups in London after this period; however, I mainly spoke informally with people and collected personal notes in written format. I continued to participate and observe the developments online until April 2013 as that marked the end of the production period of the first version of the Air Quality Egg device, and the launch of the AQE network. I continued the observations of my AQE device and changes in data platform until March 2015, when the final sensor of my device became inactive.

3.3.2. Virtual Ethnography - Online Space and Action

Following the field site as a network approach permits one to see an online environment as a site in spatial network configurations, where some of the study's entry points can be located. The core data from the online sources were gathered during 2011-2013. Some context data are also taken from websites visited during the write-up period of 2014-2018. As several sites have gone offline, or have been redesigned during these years, the access to such sites and their histories were gained by the use of http://web.archive.org and its ‘way back machine’.

Describing his ethnography of the Internet, Daniel Miller (2013) noted that “Online activity was always relative to offline, it was after all the same people” (Miller, 2013:para 4); thus, as he argued, the term virtual is often seen as incorrect in describing activities online. However, as this study will evoke data gathered from online spaces, I have applied here the methods used in and what was described by Christine Hine as *Virtual Ethnography* (2000). In her book, Hine argued that there were two distinct ways of viewing the Internet, each suggesting a different idea of the field site.

> *The first view of the Internet is that it represents a place, cyberspace, where culture is formed and reformed./-/ The second way of viewing the Internet is that it is a cultural artefact. This approach sees the Internet as a product of culture. (Hine, 2000:9)*

This study will mainly focus on the first view, and explore online space as a place and context for communal action, where the cultural artefact of the Internet of Things is formed and produced. Hine, in 2000, also observed that the “Key locations on the Internet emerged through the focus on specific websites” (Hine, 2000:105). Today, in a context of Web 2.0, the focus shifts to the platform and their specific sites, such as meetup.com, kickstarter.com and pachube.com (later known as xively.com). Thus, as already noted (see chapter 2.2.1), the Internet of Things is a product of the Internet, and specifically of Web2.0 culture. Furthermore, the community-run sites on platforms such as wiki, google groups and twitter.com have informed this study.

To document the interactions online, in places where the community could be traced, I have often used screenshots. In a context of Internet ethnography, Beaulieu (2004) has described such screenshots rather poetically as “frozen in terms of space and time and functionality” (Beaulieu, 2004:152). She argues that they “provide stability to the object of inquiry, and enable at least part of the object to be seen by readers subsequently, as it existed when visited by the ethnographers” (Beaulieu, 2004:152). This has been particularly valid and useful in a context for our enquiry, as often websites and sometimes the whole repositories have been changed or taken offline before their study has been completed.

3.3.3. Linguistic Ethnography – Meaning in Action

Some have argued that in the so-called Western world, both participants and researchers live in an ‘interview society’ (Silverman, 1993, cited in Holstein and Gubrium, 1995; Forsey, 2010), one which has raised the importance of interviews and sound, and that language analysis is as much a relevant data source as visual observation (Hockey, 2002). Rampton (2004) argued that it was likely, when scrutinising discourse data for signs of ‘creative practice’, in which “tensions at the very edge of semantic availability, active, pressing but {are} not yet fully articulated” exist, so that “specific articulations - new semantic figures - in material practice” may be found (Rampton, 2004:7). Linguistic ethnography - practised in European countries - is closely related to its sister field of linguistic anthropology, a recognised sub-discipline within American anthropology that is an interdisciplinary field dedicated to the study of language from an anthropological perspective.

> *Linguistic anthropologists have regarded language as a sophisticated sign system that contributes to the constitution of society and the reproduction of specific cultural practices. In addition to being a powerful tool for exchanging information, language has been shown to play a crucial role in the classification of experience, the identification of people, things, ideas, and emotions, the recounting of the past and the imagining of the future that is so critical for joint activities and problem solving. (Duranti, 2004:2)*

Both linguistic anthropologists and ethnographers use a variety of methods, including grammatical analysis of texts and speech acts, by searching for grammatical markers, pronoun use, turn-taking, narrative structures, overlapping utterances, the already-mentioned frame analysis (Goffman, 1974), vernacular use (Coleman, 2010), and other linguistic features and grammatical forms elicited from native speakers, or from recordings of speech events. Linguistic anthropology helps us to investigate how language use both presupposes and creates social relations in cultural context (Goffman, 1974; Silverstein, 1985; Duranti, 1997; Agha, 2006). While looking to language for concrete examples of effective (and ineffective) social action, it obtains insights from linguistics (Eckert, 2000), qualitative sociology (Goffman, 1981) and cultural anthropology (Street, 2005; Wortham, 2008).

Common to both linguistic anthropology and linguistic ethnography is a specific approach derived from question-posing. Duranti (2003), narrating the history of linguistic anthropology, points out that "in contrast to earlier generations of students who started from a fascination with linguistic forms and languages, students today typically ask questions such as 'What can the study of language contribute to the understanding of this or that particular social/cultural phenomenon?'" (Duranti, 2003:332). Such a question does not consider language as the primary object of inquiry, but rather regards it as an instrument for gaining access to other complex social processes. Rampton (2004), in the UK context, calls this a 'bottom-up' question: "what more general issues can the description and analysis of my experience help to clarify?" as opposed to a 'top-down' one (Rampton, 2004:15). It is from such standpoints that the tools of linguistic ethnography will be used in this study.

As linguistic ethnography offers descriptive and analytic procedures for investigation, within the temporal unfolding of social processes, of persons, situated encounters, institutions, networks and communities of practice, its methods of combining ethnography with linguistics and linguistically sensitive discourse analysis seem to be ideally suited for investigation of the actors’ perceptions in this current study. Thus, as I discussed in Chapter 2 concerning my intention to move away from the actor-network theory (ANT) approach and the 'flat ontologies' of its earlier stages, the study of language and linguistic form can help to uncover the otherwise suggested diminishing role of the human agency (See Chapter 2.2.3). As Ahearn (2001), in her thorough survey on meanings of agency within a broad field of academic practice points out, while broadly speaking “agency refers to the socio-culturally mediated capacity to act” (Ahearn, 2001:112), it is much more complex and often difficult to articulate. As linguistic anthropology treats language as a form of social action and sees it as inextricably embedded in networks of socio-cultural relations, it is well situated to uncover the meanings in action. As meanings are often co-constructed, so is the social reality. From such a standpoint, “language does not merely reflect an already existing social reality; it also helps to create that reality” (Ahearn, 2001:111).

3.4. Organisation of The Study, Data Corpus and Analysis

3.4.1. Background and Data Corpus

The core data corpus for this study was collected in the period between Nov 2011 and May 2013, with the additional online data retrieved in the period from 2013 to 2018. It should be noted that the later data is less related to the study subject, but rather forms contextual data that has informed the analysis of the core data. The total data corpus of this study is comprised of 810GB of original video recordings and 2GB of video recordings received from New York and Amsterdam; a collection of platform screenshots taken in the period between 2011-2013; data records of the AQE, unformatted and published, during the period between May 9th, 2013 - May 10th, 2015; observations of meetup.com of several communities: IoT London, IoT/sensmakers in New York, Sensmakers in Amsterdam, IoT Madrid, IoT

Barcelona and IoT Munich, IoT Berlin and IoT Zurich; observations of the AQE campaign site on Kickstarter.com; postings on the AQE wiki site and forum; blogs and articles published by community members on their personal sites, as well as on other online platforms such as Twitter, Prezi, Flicker, Postcapes; personal notes on observations; and a collection of a significant amount of media articles on a variety of IoT discourse-related issues.

As noted, the study is divided into three parts. The focus and data sets used in each part of this study, as well as specifics regarding the methods of analysis applied, are discussed next.

3.4.2. Study Part 1

The first part of the study is aimed to uncover questions that could help us to understand the underlying motivations of this community, the borderline markers of its formation, as well as the discourse frames employed in its speech. The questions addressed in this part are: Who are the members of this community? What are their individual motivations for participating in the project? How do they envisage the IoT development? Why is it important for them to engage with the development of the IoT? These questions not only help to understand this community's formation, but also illuminates larger discourse frames at the core of the IoT debate, as perceived by this community. Thus, the entry points here are the perceptions of individual members and the analysis of their spoken language.

This part of the study is based on selected data extracted from the transcripts of nine video interviews conducted during the two-day public workshop at the Citizens Cyberscience Summit in London, February 17-18, 2012. The two-day AQE workshop was organised as one of the 10 Citizens Cyberscience challenges (a practical part of CCS2012). The two-day workshop was one of the rare opportunities for the ‘coming together’ of the key players of the Pachube community to collectively further the development of the AQE project, both technically and socially[114]. The Amsterdam community, at this event, was represented by the IoT

114Participants were from Americas, Netherlands and London.

Amsterdam community organiser Casper Koomen[115], Alex Roester, a software consultant and lead developer of the first AQE prototype, and the ethnographer Dorien Zandbergen[116]. The New York community was represented by the two aforementioned developers - Leif Percifield and Joe Saavedra - but also, to an extent, by Ed Borden, the Pachube community organiser, who was himself not only from New York, but had close ties to the Sensmakers community there. There were also two members from Public Laboratory. In London, these two groups were joined by: two young software developers from Pachube, Ilya Dmitrichenko and Owen Davies, both in their twenties; the aforementioned freelance consultant Paul Tanner; Alison Wheeler[117], an open source developer and activist in her sixties; and Martin Dittus[118], a community researcher in his late twenties, who subsequently wrote his MA dissertation on the Pachube data corpus. The events were also attended by the London IoT community organiser Alexandra Deschamps, who was also interviewed, and several others associates.

The interviews conducted vary in length. This was due to the circumstances in which they were conducted; some were held during the workshop action, while others were set as one-to-one conversations. While some of the interviews appeared in a publicly available documentary which was published online, for the purpose of this study I have coded the identities of the interviewees. This is mainly for ethical reasons, to anonymise the individuals, as the transcripts used here extend beyond the published words available online; and for reasons of abstraction as it is their collective voice that is of interest here.

By using the tools of linguistic ethnography (Duranti, 2004; 2010) this study of individual motivations and speech aims to uncover meanings people assign to the different actors and agencies at work in both contexts: the IoT and the community. The use of words and sentences as a unit of analysis, coupled with context and gesture analysis can provide us a way to analyse individuals use of language, its relation to shared speech community, and perceptions about norms and cultural significants. This could be also one way to analyse the discourse[119]. Yet, in this work

115See more on his work here: http://www.casperkoomen.nl/en/
116See more on Doriens research here: https://dorienzandbergen.nl/
117See more on Alison here: https://alisonw.info/
118See more on Martin here: http://martindittus.info/
119See Duranti, 2010:133 on linguistic anthropology and the ways it relates to discourse analysis.

I have also adopted adopted the use of linguistic frame analysis to fore this thesis interest in larger IoT discourse, and this community's relations with other discourses that have bearings on their perceptions. The use of frame analysis is characteristic in the studies of social movements and collective action (Benford, 2000). The method of frame analysis was developed primarily by Erving Goffman (1974). For Goffman, frames represented "schemata of interpretation" enabling individuals "to locate, perceive, identify, and label" occurrences within their life space and the world at large (Goffman, 1974:21). Frame analysis helps to recognise and organise subjective context, enabling the representation of the lowest number of levels of frames and awareness that are needed to make valid interpretations of any particular piece of discourse. For example, the elements of the 'communication frame' include a message, an audience, a messenger, a medium, images, a context, and especially, higher-level moral and conceptual frames (Lakoff, 2010). The 'generic frames' are also sometimes called the 'master frame' but, for our purposes, we will use the term 'action frames'. Action frames are derived from the master frame, and are commonly used in the context of collective action framing (Snow and Benford, 1992)[120]. As Gamson points out: "A crucial feature that distinguishes collective action frames from a schema and other related cognitive constructs is that collective action frames are not merely aggregations of individual attitudes and perceptions but also the outcome of negotiating shared meanings" (Gamson, 1992:111). Furthermore, 'diagnostic framing' (problem identification and attributions), 'prognostic framing', and 'motivational framing' (Benford, 2000) may also be used in this analysis. The analysis will also adopt the measures for frame recognition, or what Gamson and Modigliani (1989) called the framing 'devices': metaphors, catch-phrases, exemplars, depictions, and visual images. Todd Gitlin has summarised the principles of frame analysis most eloquently as: "Frames are principles of selection, emphasis and presentation composed of little tacit theories about what exists, what happens, and what matters" (Gitlin,1980:6).

120Benford (2000) has argued for the recognition of what he called collective action frames that "function as innovative amplifications and extensions of existing ideologies or constituents of them. 'Collective action frames' involve the generation of interpretive frames that not only differ from existing ones but that may also challenge them."

3.4.3. Study Part 2

At the centre of the second exploration is the practice of this particular community that aims to address the ways they went about creating the air quality measuring device and subsequent air quality egg network, as well as how the nature of online and offline spaces influenced their acting together. In particular, this part also draws on an extended field of IoT enquiry, and the influence it has on practice. Questions asked will include: What are the physical and technological elements that comprise practice in the IoT framework? How is this space negotiated? What are the methods of production they chose to employ? How did the spatial configurations they embraced foster or impede their aims and outcomes? What is it they produced? How can success or failure be measured to evaluate the practice and conditions they faced on their journey? While entry points here are various spatial configurations, the study also looks to expand the understanding of how production processes are facilitated or impaired by hybrid spatiality, and what we can learn about collaborative culture in a framework of the IoT.

This part of the study combines the analysis of: language, spoken and written; observations; artefacts, physical and virtual; interfaces captured as screenshots; PR materials; and media articles published about the group's actions. The research combines multiple data sources collected in offline and online spaces. The main events observed in physical space are the already-mentioned AQE workshops held during the Citizen Science Summit 2012 (CCS) on February 16 and 17, 2012 at UCL, London, and a two-day workshop held at the Centre for Creative Collaboration (CCC) in London, on March 28 and 29, 2012. Research is also informed by other AQE project workshops held in New York, Amsterdam, Chicago, Madrid and Barcelona, and video documentations of these workshops published online (see Appendix I and IV). The community's online actions are captured and data retrieved from a number of online platforms used and appropriated during the AQE project development during the period 2011 to 2013. These include the aforementioned meetup.com, kickstarter.com, pachube.com, and the community's own spaces on wiki, github, as well as google.groups mailing list. The study also draws data from publicly available documents, online sources, images and research notes, and adopts tools such as Way Back Machine and screenshots of other AQE community-related sites. (See the full list of sites used in Appendix IV).

The method of analysis combines those used in classical ethnography (Silverstone, 1990; Silverstone, Hirsch and Morley, 1992), linguistic ethnography (Rampton et al., 2004; Duranti, 2001; 2004), virtual ethnography (Hine, 2000; Beaulieu, 2004) and ethnographic action research (Tacchi et al., 2003). Furthermore, by applying elements of discourse analysis, with its methods of narrative, content and context analysis, the study aims to unveil how both the space and the social is constructed both by human and non-human entities in everyday practice (Ellingson, 1995; Fairclough, 1995; Hardy et al., 1998; Covaleski et al., 1998; Phillips and Hardy, 2002).

3.4.4. Study Part 3

The public coming together of the key advocates of the Open IoT, and collective deliberation during the two-day Open IoT Assembly, served as the field site and the entry point for the third part of this study. This part aims to illuminate the political and power relations that not only mark the borderlines of this community, but also crystallises the conflicts within the broader IoT discourse. This part looks at questions such as: What matters most for this community in the context of wider IoT debates, and why? How, by means of language analysis, can we crystallise the perceptions of emerging issues in the IoT context.

The Open IoT Assembly took place June 16-17, 2012 at the London Google Campus. This was the largest, and the final, public event organised by the Pachube community, and its aim was not only to gather key players of IoT at that time, but also to collectively develop principles for the Open Internet of Things, or what they called the Open IoT Bill of Rights. During the two-day event, a total of 16 hours of footage was captured, covering almost all the events taking place in the main hall[121], with the exception of one keynote speaker who explicitly asked not to be recorded. A total of 22 separate events were identified. These were four keynotes, eight group

121 The number of parallel group discussions also meant that some of these were only recorded partially and that, at times, there were sound overlaps that later presented difficulty for the transcription process.

sessions, three unconference events, one panel, two round-up events and four interviews. Those segments were later transcribed, and formed the core of the data corpus used in this part. The main data corpus is made up of 69024 words. The video recordings were made on two separate digital cameras. While there were about 100 participants in the physical space, many joined the discussions online, most notably on Twitter.com with the marker #OpneIoT. The research is also informed by these tweets, a total of 684made by 93 individuals. The majority, a total of 138 tweets, was made by one individual, and one tweet was made by the Bablino - an early example of an IoT blogject, a bubble machine that spits out bubbles if its own name is mentioned on Twitter[122]. The feeds were also aggregated live on www.scribblelive.com. Other Open IoT content that has informed this study has been retrieved from online outlets such as prezi.com, flickr.com, postscapes.com, storify.com, and lanyrd.com.

To determine the common concerns across this two-day event, the quantitative method was applied to identify the most uttered words in this data corpus. The analysis of the combinations of words was then carried out to identify which words were mostly associated with each of the top five identified concepts, and the combinations of which scored the highest, and in what contexts. After this statistical analysis, methods of discourse analysis (Ellingson, 1995; Fairclough, 1995), frame analysis (Gitlin,1980; Benford, 2000; Lakoff, 2010) and thick description (Geertz, 1973) were applied to further unravel the meanings of the key concepts in the different speaker utterances.

3.5. Conclusion

This chapter has addressed the issues related to the framing of this study, the nature of the community, the data corpus, and the methods of data collection and analysis. First, the chapter unveiled the framing of this study. The overall study was framed both as an intrinsic and instrumental case study. While it aims to provide rich insight into a historically-located phenomenon, i.e. the workings and processes of one group of early IoT adopters, I argued along with Stake (2008) and Yin (2003), that the role

122For the duration of the Open IoT Assembly, Bablino also responded on #openiot.

of the case study is to act as an exploratory tool that, in the case of this thesis, helps to expand and generate theory about social practice, and its contexts - the IoT.

Second, the chapter addresses the strategies relevant for the initial analysis of this community's formation and why I came to address them in terms of a community of practice, in a context where other naming strategies could have been applied. I have argued that it was the focus of their practice and the insistence of this community's participants that has led me to frame their initial identity in terms of the community of practice. I also highlighted the fact that during the two years of my observations, the community formation endured several transformations, contexts of which make other conceptual frameworks relevant. Furthermore, to acknowledge the fluidity and changing nature of any framing activity, it was indicated that the first part of the study would pursue an in in-depth analysis of the participants' own perceptions on what constitutes this community, its borderlines and associations. Thus, at this stage, any rigid frame application could only be used as a starting point for this investigation.

Following this, the chapter discussed the nature of the ethnographic approach, i.e. study field as a network, and the chosen methods of data gathering and analysis. I argued that the nature of this community, its geographic distribution and temporary nature, required a multi-method approach. The chapter then looked at the number of ethnographic approaches adopted. Besides the use of classical ethnography and its methods of observation, the chapter has highlighted the use of action ethnography - in particular, its use in a context of data gathering, virtual ethnography, and its application in the study of online spaces and content - and the use of linguistic ethnography in the analysis of the participants' language, both spoken and written.

Finally, the chapter laid out the premise for each section of this three part study, the nature of the total data corpus, and the specific data corpus components utilised in each of the segments. As indicated, the first part of this study aims to address the participants' own perceptions on what constitutes this community and the IoT. The core data used in this part is one-to-one interviews with participants, primarily collected during the two-day workshop in 2012 that brought together developers from Amsterdam, London and New York. As human knowledge is language-bound, the linguistic analysis of grammatical markers, context frames and units of participation is the method chosen to access participant perceptual strata. To address the matters of practice, the second part of this study will use a multi-ethnographic approach in the analysis of: the organisational and design methods employed, the spatial practices, the success or breakdown of campaigns, the nature of created devices, the AQE network, and the legacy of this community's collective action. The multitude of data sources and methods used in the analysis were discussed. The third part of this study will return to the linguistic analysis of the participants' speech to identify the key concerns in the IoT domain. The data corpus, comprised of conversational data and speech utterances, collected during the two-day assembly of the network of the Open IoT advocates, is used in this segment of the study.

PART II

EMPIRICAL STUDY

4

SENSE MAKING:
MAPPING THE PERCEPTION IN LANGUAGE

4.1. Introduction

To perceive is not to experience a host of impressions accompanied by memories capable of clinching them; it is to see, standing forth from a cluster of data, an immanent significance without which no appeal to memory is possible.
(Merleau-Ponty, 2008:26)

In this part of the thesis, I begin the study and analysis of the language and practice of the early adopters of the IoT. This first part of the study will turn to an analysis of language to uncover perceptual insights from the participants' own perspectives. The focus here is turned towards a group of people who came together from different countries, diverse walks of life, driven by a variety of motivations. On the occasion of the Second Citizen Cyberscience conference in UCL, London (Feb 2012), the group came together to further the development of the Air Quality Egg (AQE) device, a project that came out of IoT community meetups, and was supported by Pachube[123]. While the next chapter will offer a closer look at how and what the group did during this and other similar events, and what it was that they built, this chapter will focus on an analysis of the participants' speech to uncover what the developers in this community thought they were doing, and why they were doing it, what motivated them, what values they held and, how they perceived the emerging IoT phenomenon.

123I will use the name of Pachube in this study rather than Cosm or Xively (later names used for the company). This mainly reflects that the speakers here mostly made reference to Pachube and that the interviews were made before the public renaming of the start-up. It is also worth noting that Pachube is often referenced as a platform, start-up or company, as well as group of advocates, which I will here also refer to as the Pachube community. The AQE project will be discussed in more detail in the next chapter.

This part of the study adopts the view that one way to gain access to another person's perception is through description, and the examination of conceptual content and its organisation in language. The data corpus for this study is formed by nine interviews conducted during the two-day gathering in UCL, London. It is worth noting that this was an early stage in the prototyping of the AQE device. This is reflected by the way the speakers talk about the project and their relationships with it, often expressed in the form of a future vision of what would or might happen when the devices were made and distributed. This also prompted the questions asked in the interviews to go beyond the AQE project framework, and inquire about the broader context of the IoT and hacking culture. The study will examine selected speech examples taken from these interviews to ascertain motivations for participation in this event, the participants' ongoing relationship with the IoT community, and their perceptions of what mattered in this given context. Furthermore, the study will probe the linguistic markers that determined the inner workings of this community and the ideological frameworks applied. For example, while talking about their present motivations, participants would often invoke fluid relationships with past events or other personal histories, or while talking about chosen approaches for the development, they revealed their perceptions on order and politics.

By applying methods of linguistic ethnography (see coding keys in Appendix III), and in particular the use of conversation analysis, to the analysis of texts that are not from conversational interaction, a method borrowed from Alessandro Duranti (1994), this study searches for indicators that may signal a certain IoT-specific character of spatial and social relationships, as well the perceived role of this community in the larger IoT context framework. For example, when the speakers reiterate their practice through their speech, they not only adopt the tools of imagination and storytelling but also, in the process, construct boundaries that not only mark the identity of the group, but also those outside this immediate space. The method seeks to identify conceptual frames, speech markers, turns, communication norms, conventions and registers, as well as observe hesitations, pauses and gestures in relation to situational surroundings.

While examples of speech here are taken from publicly available interviews, published online (see Appendix II) for the purpose of this study, the identity of the speakers is anonymised and coded according to the following three categories:

IC - interviewee coder AQE core team
IO - interviewee community organiser
ICI - interviewee coder independent

The categories were primarily derived from the way the participants introduced themselves. Thus, it is their perceived role in this community rather than their exact identity that is of most interest here. The related code number is selected randomly to make a difference between speakers of the same category.

4.2. Modes of Identification

One of the initial questions all interviewees were asked was to introduce themselves and describe how they came to be at this event, and how they became involved with the Internet of Things and the AQE developer community. All participants were recorded on camera and informed that part of the interviews would be used for the documentary of this event, and a part for the further study of the IoT community. The presence of the camera and knowledge that some of the material would be made public might have put some pressure on participants, as shown in the example (1abc) below. However, while a majority of participants seemed to be well acquainted with the art of public speaking, and what could be called self-promotion, their role in the community structure most likely also determined the level of their desire to contribute to the promotion of the group's work, and the aims of this community[124].

As noted already, the key participants interviewed came from three different cities: Amsterdam, New York and London. Example:1 is taken from an interview with one of the community organisers who was not from London, but who arrived at the event directly, on the morning of the first day. As participants arrived and gathered, the morning could be characterised as a slow start during which people mainly introduced themselves to each other and became acquainted with the space. It should be noted that this was the first time the members from the different cities had met each other. Thus, as this example will indicate, they most likely had not had time to

124I make a separation between the group of developers working directly on the development of the AQE device at this event and the larger community of AQE project advocates and supporters.

coordinate their individual alignment with that of the community's. On my initial question asking to describe his role and his involvement in the IoT community, participant IO_2 introduced himself as the community organiser from city x and then said:

Example: 1a

1. *'I work with Pachube and running their Internet of Things community there.*
2. *Em...*
3. *I manage...*
4. *organise workshops and em...*
5. *sorry can we start over again?'*

Example: 1b

1. *'I am from city X. I am involved with the Internet of Things community there.*
2. *Actually, I am em...*
3. *…............I am in charge with organising workshops, events em... in X'.*

While these two examples describe the same phenomenon, i.e. the participant's involvement with the world, the slightly different framing of each commits the speaker to a distinct level of claims, a particular structure of the community in question, and his involvement in it. Example:1a signals the speaker's relatively significant role in a community-organised event, thus his claim to an active role of leadership of this community. Such framing signals a somewhat hierarchical structure in this community, where leadership plays a considerable role. Example:1b assumes a less organised and more abstract shape of a community where the participant is 'just involved', like any other participant. Observing the participants' hesitation after his statement in Example:1a, I initially felt it was due to him being uncomfortable in a front of the camera, as IO_2 explained his hesitation in line 5 with the utterance: '*sorry can we start over again?'*, followed by: '*there is so much background noise, it's distracting me'*. However, the change brought about by the different framing of his utterance in Example: 1b uncovered some insight into the participant's preferred use of an ambiguous frame in the contexts of his involvement and the community structure, indicating a dissonance between his personal motivation and his role he presented here or, in other words, his alignment with the context. The interview followed with one more question but IO_2 asked to postpone the interview to a later time as he did not feel adequately prepared at that time, which, as I have already noted, was early, on day one of the two-day workshop.

Interestingly, on day two, when the interview resumed, IO_2 had ‘sharpened up’ by broadening the perspective (see Example:1c) on his own motivations for involvement, while keeping the framing observed in Example: 1b intact. This might indicate the participant’s perception of how he believes the community should be organised – possibly more decentralised, without any leadership roles. As Duranti (1994) points out: “each grammatical choice made by the speaker can be politically relevant. It presents certain events as valuable or damaging for the community” (Duranti, 1994:4). With that in mind, by clearly stating his role as a key organiser of the community (Example:1a), the participant might have endangered the perceived nature of the community, motivations of other members, and its organisational structures; thus, correction was needed. However, his role as a community organiser indicates aspects more commonly present in learning communities where the leadership role on the whole is more recognised (Kilpatrick, 2003). This not only suggests a certain shift or a possible variation in community format, from what might be perceived as a correct or incorrect formation of the community, but also the importance of the learning aspect of this community, thus pointing not only to the fluid nature of what we have here identified as a community of practice, but also the learning aspects of CoP identified by Lave and Wenger (1991).

Example:1c

> *‘I have a design background but I love new technologies and especially what new technology can do for people, people’s lives, and how can technology make the lives better on our planet. That’s why I am involved with the Internet of Things community in X and Pachube. Because I think the IoT is a revolutionary development in our society, especially on a social level, not only on a technological level but on a social level.’*

I will return to closer analyses of concepts and meanings participants use to describe their visions of the IoT later on. However, what can already be observed is the close association between Pachube, the Internet of Things and notions of community. Or in other words, the values assigned to both technological and social aspects of the IoT. Furthermore, by involving the broader rhetoric of IoT discourse as a ‘force for social change’ or ‘revolutionary development’ (in Example:1c), the participant exhibits what Dell Hymes (1972; 1974) called *communicative competence*, one of the key factors in defining a particular community of speakers. As Duranti (1994) restates: "to be a competent member of a given speech community means to be an active consumer and producer of text that exploits *heteroglossia*[125]"(Duranti, 1994:5). The access and ability to use the communication norms, conventions and registers is a crucial component of power relations in any given community. Heteroglossia introduces the broader sociocultural and contextual information that speakers possess, thus allowing us to understand their discourse references and, through that, their perception of the 'world'.

In Example:1c the speaker not only exhibits his communicative competence by the use of heteroglossia of IoT discourse but also, by emphasising a social change promised by IoT developments, the speaker makes the distinction between his motivation and what was to subsequently distinguish the Pachube/IoT community from other technological developments in this field, by aligning its motivations with the betterment of the social and the planetary. In Example:1c we can observe language in action. Firstly, the speaker sets a background; then, by using the assertive 'I love', the speaker not only tells the audience how things are but he also declares his love as a designer for new technologies. By using the transitive verb 'love' the speaker (agent) introduces the object – the technology that becomes an instrument in cross-event relations, and the reason for his actions. Through this, the speaker has introduced the background, the key actors and the broader considerations in which the discourse of the present is enacted.

In Example:2, in response to the introductory question, the participant (IC_4) similarly introduces the background of the broader discourse by mapping out his involvement with what here is assigned as a group, rather than a community. While by using the referential indexical 'I' the speaker signals his being a 'part of a group', his perception of it seems to be more casual, possibly with weaker ties, describing more of a network type of connection. This reveals both a perception of this group as a network-like structure, but also uncovers network logic in which both human and

125A concept introduced by Bakhtin (1981) in the context of a discussion about centralizing tendencies in the life of language and its counterpart dialogised heteroglossia, organized in the 'low genres' or language of street performers, clowns and other socially specific groups in medieval cities. It describes simultaneous existence of multiple norms, forms and conventions. See Duranti (1994).

non-human entities are interlinked. The indexical ‘here’ (in lines 1 and 9) is pointing to a deictic centre – this event, this place, where the group, which he is a part of, assembles. Likewise, the subject marker in relation to the verb ‘working with’ (line 1) in the present continuous, is both the referential indexical ‘I’ and the ‘group’.

Example:2

1. *‘I came here as part of a group working with Pachube*
2. *on a couple of different things.*
3. *The project I am working on is engaged with Pachube because it is the... the...*
4. *…....the recipient of data that I am creating from my sensors.*
5. *And then I have been involved*
6. *...working with (IC_3), (IO_1) at Pachube*
7. *in creating the air quality network...*
8. *…............air quality egg device*
9. *that they have been playing with and hacking on here.*
10. *So both things brought me here ...to talk about that’*

Like speaker IO_2, speaker IC_4 exhibits communicative competence as he not only introduces himself through his association with this community but also through the introduction of discourse-specific vernaculars, such as 'sensors', 'data' and 'device', and their network relationships. In line 3, we can observe how the subject, in the present continuous tense, assigns the linguistic agency to a ‘project’ that has some relationship in the present perfect with Pachube, away from the subject. The object marker ‘it’ points towards ‘Pachube’ as an instrument or repository, the passive ‘recipient’ of active ‘data’ that moves toward the instrument or container ‘Pachube’. Thus ‘data’ here is both in a domain of object and action. As an object, it is ‘created’ (in the present continuous) by the subject using his ‘sensors’ – the instrument, while in relation to the recipient, it is in action as it is being created and thus received in the continuous mode. It is unclear here what type of ‘sensors’ the speaker has in mind, other than they are the sensors that belong to him.

The second part of this sentence (line 4) is an example of a spatial indicator pointing in the direction of other aspects in a sociocultural context, such as the surrounding space and another place. Here we can observe the movement that is most likely that of data from the (unknown) sensor (which is most likely a technical device equipped with sensing capabilities) to a speaker/subject, from the speaker/subject to data, and then to a data recipient. As can be observed in the linguistic composition, data does move through the subject, i.e. the speaker, while in the technological system, it is most likely that it travels in the following order: sensor device>router>network>repository, crossing many other switches in between. I will return to the closer analyses of device/data relations later. At this point, if we look at lines 3 and 4, there is another peculiarity. There is an on-going tense to this sentence, and it is not clear if the subject is working on this ‘here’ or if the project the speaker refers to is purely for setting the background.

However, the following lines 5 and 10 correct this uncertainty. They do so by continuing an account of his involvement with the use of the sentence connector ‘then’ (or subsequently) followed by the subject indexical ‘I’ and present perfect verb ‘have been involved’, immediately followed by line 6 with the use of the preposition ‘(working) with’ and then stating two named actors within the group. This not only indicates his past participation ‘in creating the air quality network’ (line 7), but also his current involvement with the members of the group (line 6). Line 10 reiterates his involvement in both his and group’s projects as a reason for being ‘here’. The use of the preposition ‘at’ in relation to Pachube also signals his perception of Pachube as something that resembles a place of work, thus expanding the space of Pachube not only as a repository of data but also as a social enterprise. The short pause made between the ‘air quality network’ and ‘air quality egg device’ indicates the speaker’s readjustment of terms. Initially referencing the network as in line 7 - *‘I have been involved in creating the air quality network’*, after a short pause, the speaker corrects himself by replacing the word 'network' with the word 'device', thus creating a correct meaning that would sound, if uttered, the same as in line 8: *‘I have been involved in (developing) the air quality egg device’*.

The initial utterance in line 7 (‘the air quality network’) is a much more abstract and ungrounded concept as it does not resemble any real or material phenomenon. However, the members of this group of developers often evoke a vision of a network that they are attempting to build between the air quality sensor devices and their social counterparts. Recognising that the sentence ‘the air quality network’ does not make grounded sense, the speaker corrects himself by confirming his involvement with the development of the Air Quality Egg device. The device named here specifically references a particular design of technological and design solutions this group of developers are working on. However, this often-observed confusion, between the device and the vision of its distribution that would determine the subsequent establishment of a network between numerous such devices and possibly their owners, affirms not only this group's identity, but also forms part of its heteroglossia.

The insight into the development process of this device is offered in line 9, in which the speaker firstly, distances himself from the involvement in this particular action, which is taking place at this event and space in time, by use of the markers ‘they’ and ‘here’; and secondly, chooses to characterise the process taking place ‘here’ as ‘playing and hacking’. This on and off mode of being involved and then not being involved, or being able to step aside when ‘they’ might be ‘playing and hacking’ something one has contributed to, could be characteristic of individual power and free will within the group setting, as well as an attitude many geeks express due to the nature of trial and fail processes involved in developing technological systems (Coleman, 2008).

While the above examples illustrate the two most commonly expressed reasons for being at the event and joining this group - a) the belief in a common good and a need to organise, and b) the technological use of Pachube or the technical know-how and ability to contribute to the development - there was a third distinct line of motivation, illustrated by Example:3. On the question of why the participant came to the Air Quality Egg challenge workshop, participant (ICI_6) responded:

Example:3

1. *I breathe, therefore I am ((LG))*
2. *Or more to the point I am very concerned about somewhat my mother*
3. *who is 84 and she lives indoors with a gas central heating, which to me [??]*
4. *and she has problems with breathing*
5. *And I think that’s the issue*
6. *[??] people live in centrally heated homes, they don’t have fresh air,*
7. *they don’t have windows open anymore*
8. *now...purely... ((shakes head)) ...*

9. *<u>we don’t know what the quality of air is</u>*
10. *<u>and I want to know</u>*

In Example:3, we observe that the motivation that has brought ICI_6 to this workshop is personal or, in this case, is a concern for some other person outside the ‘here and now’ - her mother. Line 1 is a joke often cracked within the group, and observed on other occasions. As such, line 1 expresses the participant’s inside knowledge or vernacular, thus her belonging to this group. Appropriating Descartes’ ‘*Cogito, ergo sum*’ (I think, therefore I am) and delivering it in a proud manner, followed by laughter, the participant not only demonstrates her scientific drive but also makes an internalised statement i.e. to be is to know, and to know now means to know what one is breathing. Lines 9 and 10 confirm this, as the speaker expands on it by stating ‘because we don’t know, I want to know’ – a scientific curiosity pointing to both geek and citizen science frameworks being evoked here.

In lines 3 and 6, the participant also points to very distinct places and special configurations in a physical world. She uses specific terms such as 'indoors', 'with central heating', 'centrally heated homes', 'don’t have windows', all representing measurable qualities of a space. Her initial concern for her mother is clearly expressed in line 2. At the end of line 3, due to the noise levels, some sound on the recording has been lost; however, it is apparent that the participant has expressed distrust in her mother’s living situation - ‘indoors with gas central heating’. Line 4 indicates that her 84-year old mother also has a health issue – 'problem with breathing'. In line 4, she confirms her conviction that it is the ‘gas heating’ and ‘indoors’ that are the reasons for her mother’s bad health. She reiterates her concern, in a passive voice in lines 6, 7, 8, by making her argument more generalised, i.e. about the ‘people’. Line 8, with the utterance ‘now...’ and a statement followed by ‘purely...’, followed by the shaking of her head, signals much more strongly her own conviction: that all these physical world matters - 'indoors', 'gas heating', 'closed windows' - are the reasons for poor air quality, and subsequently for human ill-health.

In line 9, the participant uses a passive indexical ‘we’ in claiming a generalised, possibly ‘all human’, desire to know what the air quality is. However, the indexical ‘we’ could also refer to another group of concerned people, related to the situation she describes or the physical place where her mother lives. Whatever the case, the participant has used the passive voice and made a generalised statement that involves a larger interest group. One might wonder why this participant, knowing all the problems described above and the fact that ‘windows don’t open anymore’, does not try to open these windows. If we focus on two referential indexicals in line 5 and line 10, the motivation becomes clear. In line 5, ‘I think’ is a reason for ‘I want to know’ (line 10); both are strong statements that indicate the power possessed by the participant.

Here lies a peculiar characteristic that can be observed in the speech acts of these participants, as well as can be noted frequently in the broader context of IoT discourse. When participants talk about problems in the physical world, they often use the impersonal voice which signals their inability to act or make a difference. In line 5 (Example:3) the participant uses ‘I think’; however, (most likely by using common sense), the participant already ‘knows’ that the air is poor if the windows are closed. The ‘knowing’ expressed in line 10 is a different kind of knowing. It is a measurable knowing that she believes could be acquired with the help of a technological device. Such a proposition reveals power relations where power is assigned not to the human agency, to one’s ability to open a window, but to a technical device that will measure, and possibly confirm, what we already know, and subsequently enable us to act.

These introductory examples not only represent the rich variety of heteroglossia and communicative competence of the participants, but also reveal some of the technological vernaculars used in speech and discourse that serve as modes of identification of a community of early adopters of the IoT. This would reinforce Coleman’s (2010) suggestion of digital media vernaculars. Subject-specific objects, such as unspecified sensors, data, recipients, air quality networks, the Air Quality Egg device, all of these can be viewed as lexicon terms of knowledge shared by the speakers. However, as seen in these few examples, this particular group of technologists or members of a community of practice, are in a constant state of negotiation. As we will explore in the next section, negotiations are occurring on different levels, often simultaneously, at once navigating between the physical and virtual spaces. While mediating the knowledge of metaphysical and empirical learnings, speakers tell the story of power relations between the individual, the state and the community.

4.3. Context Framings

4.3.1. Open Source Paradigm

As will be observed in this section, the participants in this community often evoke the open source framework when insisting that the development of the Air Quality Egg (AQE) and the examination of sensor technologies on a level of citizen science would not be possible without past attainments of open source software and hardware movements. While some of their individual practices would suggest their broader engagement with ideas of FLOSS communities, it is the particularity of open hardware contexts that, I would suggest, guide their chosen framing approach. In the context of the IoT, with its focus on materiality, it is the cheapness and ubiquity of technological components and open hardware devices, combined with collective knowhow, that has enabled this next stage of technological fabrication.

Since Eric Raymond’s (1999) essay 'The Cathedral and the Bazaar', that re-articulated the early ideas of the free software movement and its radical intent for societal change into an open source rhetoric of efficiency directed towards broader business adaptation, the open source paradigm and its later developments (open hardware, open data, open knowledge movements) have been closely associated with the ethics and practice of a global community of developers. While the community aspects of OSS have often been shown to be fallacious (Krishnamurthy, 2002), it is its ethos and philosophy (Hannemyr, 1999; Jesiek, 2003) that still motivates many developments today, be it grass-roots community-based projects or open source military concepts[126].

126For example, see the grassroots movement of diverse patriots that work for and with the Department of Defense (USA), and who believe in adopting open technology innovation philosophies for defense purposes. http://mil-oss.org/

Similarly, for this community of early adopters, this primal association with open hardware development is often seen as a starting point from which identification with open source histories is navigated. This is well illustrated by the following example, which is a response to a question about the presence and manifestations of 'community' in the context of the development of the Air Quality Egg and other sensor-based projects. Speaker IC_4 immediately referenced the connection to the open source hardware movement, or rather identified the question of community with the broader community of open source hardware and software movements.

Example:4

1. *I definitely think it's growing.*
2. *One, with open source hardware movement ...*
3. *it's been incredible …because em...*
4. *the access to these devices that allows people to connect to the Internet is*
5. *it's readily available... I mean*
6. *you can get a little Wi-Fi module that is a size of a postal stamp for 35$ now and that can upload any piece of data you want to the Internet in a lot of ways...*
7. *so... that's really enabled people to engage in it, and then...*
8. *having something like Pachube is that glue that holds it all together,*
9. *that has developed all around this, and I think it's been both*
10. *from hardware and software side that allows people to really just....*
11. *engage in it in this incredible way.*

In line 1, the speaker's utterance is shaped by, and responds to, the question about the meaning of community in the field of the Internet of Things, marked by the indexical 'It is" in the present tense, while lines 2 and 3 point towards another space-time domain in which the space is identified as continuous mass, in this case, the open source hardware movement. Line 3, with its indexical 'it's' followed by the adjective 'incredible' signals the on-going positive experience the speaker associated with the larger background frame that could be identified as 'all open source movements'. Lines 4 and 5 reiterate the particulars of that experience, such as in line 4: 'access to these devices', 'allows people', 'connect to the Internet'. The indexical 'that' in line 4 refers to a prior portion of the discourse, i.e. 'the access', that 'allows people to connect' to the Internet.

Here the background frame surfaces as the speaker refers to the open source hardware movement and the discourse that surrounds it. The open source hardware movement has been around for many years now, and has the explicit intention of contesting control over proprietary computer hardware designs, or pull manufacturing away from corporate interest[127]. The closed nature of many proprietary hardware devices is seen as a key obstacle for open public engagement with one or other hardware platforms, or in practical application - the possibility of geek intervention/hack. It is not true that people have no access to the Internet without open source hardware as many PCs, and especially Apple platform users, access the Internet via what can be called closed hardware systems. However, what the speaker here refers to (in line 4) is not the fact that people cannot have access to the Internet, but rather that it is their devices and, in particular the devices in the context of the IoT (as referred to in line 5), that ensure their access to the Internet. In other words, this creates a configuration in which people's access to the Internet is defined by the access of their IoT devices to it.

The clue to the indexical ‘these’, in relation to devices, becomes apparent in line 6 when the speaker brings up the example of the basic requirements for the device in question. However, before attending to line 6, we should briefly look at line 5 and the indexical ‘its’ that refers to a broader frame of the discourse at hand. What is readily available here? As line 6 illustrates, there are some particulars, such as off-the-shelf, cheap hardware bit, WiFi module, that can upload data to the Internet. However, the ‘its’ in line 5 points towards the much larger mass and complexity in space and time. Something that is referenced again in the utterances (lines 8 and 9) ‘holds it all together’ and ‘that has developed all around this’. The ‘it’ in line 8 and ‘that’ in line 9 reference the same ‘its’ in line 5, and in all cases references the same thing - many bits and lines of code written and published by the open hardware activists, or bits of hardware that have been developed on open hardware standards from their conception, such as the low-cost microelectronic platforms (Arduino, 2004; Zigbee, 2006; Nanode, 2011). It also, most likely, includes numerous forums, IRC chat channels, mailing lists and open, and most likely free, code publishing sites, such as github.com. All this, and a large number of physical, human bodies that

127See more on a Open Source Hardware here: http://en.wikipedia.org/wiki/Open-source_hardware; and example projects here: http://opencores.org make up the space of ‘its’ and ‘that’, that have been so ‘incredible’ and ‘readily available’, encompasses the histories of free and open source movements.

The indexical ‘this’ in line 9 refers to the upcoming portion of the discourse, i.e. a situation performed in the linguistic foreground, a development in current space-time. It could refer to IoT discourse, community developing sensor devices, data collecting/mining, or the broader citizen science movement. Line 7 is where the shift in space-time takes place. The first part of the sentence refers to the open source hardware movement (marked with ‘it’) and all that it entails (that’s), while the second part ‘and then’ signals the other space that has some additional elements, making it distinct. In line 8, the role of Pachube is made visible with its quite significant central role in the current discourse frame. The use of the ‘glue’ metaphor is powerful. It proclaims a unifying power, which is also made in the statement that it ‘holds it all together’. In the situation where ‘it’ refers to a myriad of elements that make up the wholeness of the open hardware movement histories, this acts as a rather powerful statement that not only signals the speaker's perception of Pachube’s open nature, and its role in the context of the open hardware movement, but as seen in line 11, makes a claim about its broader role as a tool for people’s engagement with the devices, and the Internet of Things phenomenon.

4.3.2. DIY Culture and the Process of Learning

As determined in the analysis of Example:4, and also observed in the expressions of other participants, it is the framework of open source, and in particular the open hardware, that is highlighted when identification frames are evoked in relation to the community and its formation. It is also the other major aspect, i.e. the cheapness of technology and its widespread availability, that is of concern here. As will be observed in Example:5, the negotiation of hardware cost is also seen as an essential aspect of the DIY culture, encouraging the spread of knowhow, ensuring experiential learning and, subsequently, the acquisition of tacit knowledge.

Example:5

1. *The other thing is … someone says*
2. *'oh, this device costs 200 quid', ...*
3. *'no, sorry I want it for 25', so I'll build it.*
4. *And...em... the actual building...*
5. *you see, some people would argue, well, em...'you haven't really saved money...*
6. *You bought 25 pounds' worth of materials but then you spend five hours building it.*
7. *You know, you not further forward.*
8. *I say 'yes you are' because the experience of building it,*
9. *it's again, it's an attitude changer.*
10. *and ..Because you know you can do that sort of stuff.*
11. *and even people who don't have...*
12. *in my case it's easier because I got a background,*
13. *but if you ..if you didn't have a background, actually building a a...*
14. *gadget, you know, something like one of these air quality sensors, em...*
15. *building something like that would give you lot of confidence about what you could do and ...so...*
16. *it is actually...*
17. *you making a cost saving and you also gain an educational experience,*
18. *so for me it ticks all the boxes.*
19. *And I reject the idea that* ***...*** *that*
20. *You might as well go out and buy an expensive gadget ....*
21. *Em..some exceptions to that...*
22. *You know, you need, for instance, you need a computer that works.*
23. *You don't want spending ...*
24. *fixing that all the time (smiles)*
25. *em...but ..em...most of the electronic stuff emm...*
26. *there is an argument for building it*
27. *and that's what these things are all about (hand movement: backwards, towards space behind him)*
28. *and this is people learning from each other,*
29. *and picking up the knowledge they didn't have, filling in gaps, if you like...*

By reflecting on what motivates him and others to participate in projects like the AQE, speaker ICI_7 identified two principal drives that we could attribute to geeks imagination'[128] (Kelty, 2008). First, it is a shared enticement that, in his view, comes

128Kelty articulated the 'geeks imaginations' in the context of the Internet, and argued that "Geeks find affinity with one another because they share an abiding moral imagination of the technical infrastructure, the Internet, that has allowed them to develop and maintain this affinity in the first place." He uses the phrase "moral and technical order" that "signals both technology - principally software, hardware, networks, and protocols - and an imagination of the proper order of collective political and commercial action, that is, how economy and society should be ordered collectively."

from a challenge to build something that does not exist. The second stimulus, identified in the example above, is the price and benefit of learning through doing. In lines, 2 and 3, the speaker uses constructed dialogue[129] in which the indexical 'I' references not only the speaker himself, but also signals his identification with the identity of a 'hacker', and thus the behaviour that implies. By using constructed dialogue in lines 1 and 3, and later in line 5, the speaker also brings to light the dialectical nature and broader social framing of 'hacker identities'. The 'someone' or 'some people' here represents the otherness against, or in opposition to which, the identity is constructed. The other is 'someone' who disagrees with saving money, or sees 'what hackers do' as time wasting, suggesting that the 'someone' is one who prefers to spend more and get only ready-made, ready to use devices. Thus 'someone' here most likely is a reference to a mainstream consumerist and a subscriber to the ready-made culture, a person that marks the perceived borders of this community, even as one that is resisting it.

Lines 8 and 9 provide a clue to the key aspect of value the speaker assigns to the hacking approach - 'experience of building it', 'it's an attitude changer'. Later, the speaker, in lines 13-17, reiterates his argument by using an example of a device, marked with the indexical 'it' (line 8), as being 'something like these air quality sensors' (line 14). Likewise, the process of building, marked by 'it is' (line 9), which is perceived by the speaker as an 'attitude changer', is explained in line 15 with 'that would give you lot of confidence about what you could do'. The notion of change in attitude resonates the desire for change in behaviour, a motive that reappears in other interviews as it sits well with the broader IoT discourse (see section 2.2). However, it is important to note that in the case of this speaker the changes in attitude and behaviour are not one and the same. While the behaviour change would most likely, in the context of the IoT, be identified with the concept of sustainability, be it through energy usage or health monitoring, here the attitude change is identified with 'confidence', and an individual's ability to act based on experiential learning, bringing to the foreground the reference to DIY culture and tacit learning.

(Kelty, 2008:28)

129 Tannen's (1989) term for what otherwise could be called a 'reported speech'.

The pronoun ‘you’ used in Example:5 (lines 5, 6, 7, 20, 22, 23) does something more than imply the existence of an addressee. It relates to the aspect of the world out there. It recognises out there as something or someone lacking confidence and not knowing what it can do. The world that could do well with some ‘cost saving’ and ‘educational experience’, as reiterated in line 17. The world of disempowered individuals alienated from the means of production. The multitude that needs on-going learning. The world as if in a permanent becoming.

For the speaker, the educational aspects and learning in the community, in hackathons such as the Citizens Cyberscience Summit, is an important aspect of knowledge acquisition and distribution, as again reiterated in more detail in lines 27-29. The knowledge is shared as it is gained by ‘learning from each other’. It is fragmented, not complete, as marked by ‘picking up the knowledge they didn’t have’ and ‘filling the gaps’. It is decentralised and distributed. As lines 11-13 indicate, the speaker acknowledges the importance of the background knowledge needed to build a device or, as used here, a gadget (degrading from the device to gadget or trivial device). However, as line 13 signals, the ‘background’, or background knowledge, can be gained by experience and actual fabrication. Thus, even if one does not have background knowledge, the experience of doing combined with the cheapness of technology could provide the needed knowledge framework and the learning process. This perception indicates already highlighted learning aspect of the Pachube community, but also the broader context of a DIY culture that argues for an IoT paradigm in which the disappearance of technology is perceived as crippling the human ability to learn and acquire knowledge about the world (see Kranenburg, 2008).

In the example above, there are two other instances that provide an opening to the speaker’s perception of the wider world, or the background frame for the present discourse. The first is the use of the idiom (line 18) ‘so for me it ticks all the boxes’, meaning something that is cheap but has the educational value that meets the criteria or expectations of the speaker. This is immediately followed by the second instance in the utterance ‘and I reject’, with its use of the performative verb, with which the speaker clearly expresses or enacts his stance against the ‘common’ or dominant argument that one ‘might as well go and buy an expensive gadget’. Thus, lines 19 and 20 are marked as a boundary frame, stating clearly the line that will not be crossed.

Interestingly, however, after a short moment of silence, the speaker repairs his statement (line 21) with ‘em...some exceptions to that’. He gives the example of a computer that works with the argument that one would not want to spend time fixing it. Similarly, the repair of the statement in line 23 is made in line 24. Instead of saying ‘spending’ (all the time), or what could be indicated as ‘wasting time’, the speaker repaired the association of time = waste with ‘fixing the computer time’, followed by a smile. Likewise, the significance here was made by ‘you know’ at the start of line 22, assuming the ability of the interviewer to manage the retrieval of information hidden in the meaning of his words.

This notion of ‘fixing {the} computer all the time’ provides us with another insight into the speaker's perception that is most likely rooted in his past experience, and is assumed to be shared by the interviewer: the roots of DIY computing, the practices of the early hacking culture, and the developments of open source (Ockman and DiBona, 1999; Marenko, 2005; Hatch, 2013; Jungnickel, 2013; Pearce, 2013). All three of these can be identified with the endless fixing of redundant computers, broken systems and the endless reinstallation of newer versions of operating systems. But then, this was the place where innovation was made and learning acquired (Landwerhr, 2014). At the same time, the technological know-how led many technically savvy people to become computer ‘fixers’, before widespread specialised computer services were available. Both these are not very positive connotations, and are associated with the past. In contrast today, computers are seen more as tools, ready to be used, while ‘most of the electronic stuff’ or 'devices' denote innovation, something still to be built, broken or fixed.

4.4. On Domain Specifics

4.4.1. Intelligent Devices

Talk of devices is present in the speech across this community. As the following example demonstrates, ‘device’ is perceived to be at the core of this discourse. For more technical participants, it is a device and its workings that hold the key to the success or failure of this next stage of the technological development, and it is in speech examples such as the one below that we can observe how the value and the agency are assigned to this actor.

Example:6

1. *The Internet of Things to me is like the idea that ...am*
2. *any any device that has input and output in general,*
3. *not not saying that Internet part already, but just*
4. *any device that takes anything in and puts anything out*
5. *should be able to report that*
6. *should be able to understand what it is, what’s its impact is on ...overall*
7. *overall network behind it.*
8. *So the idea that device should know ...*
9. *what it’s taking in at any point, understand its impact on overall system and then ...*
10. *what it’s outputting and what its impact on the overall system is.*
11. *That’s kind of my understanding on what the Internet of Things is.*
12. *So that devices can coordinate usage of materials or goods, or energy or water and then kind of focus on the outputs of that too.*
13. *Is there a way they can be more efficient,*
14. *is there a way that they can combine together usage, to not use that much, things like that?*
15. *So that’s kind of big picture I see for the Internet of Things.*

At the start (line 1) the speaker asserts that the Internet of Things for him is all about an idea. Line 2 reveals that it is not some grand idea of a unified system or socio-technical environment, but rather the idea that any device should be able 'to report' (as in line 5), 'to understand' (line 6) and that a device 'should know' (line 8). While these three are all rather reactive faculties, in line 12 the device is also thought to act upon its understanding, knowing and reporting in order to further coordinate the flow and movement of things and goods outside of it.

In other words, the ‘device that has input and output in general’ (line 2) has the ability to act. Act here, however, does not only mean in a socioculturally mediated capacity, as that is assigned to human beings, but also in a technical one, making it a techno-socio-cultural capacity. As has been discussed in previous chapters, the idea of a device as an active agent has been a part of the Internet of Things discourse from its early imaginings, as outlined by Bleecker (2006), Latour (1999) and Law (1992). Here, as in the previous writings, devices are seen acting alongside people, but also independently of people. They are seen as active participants in the construction and deconstruction of networks, in a world of inter-networked relations.

In line 3, the speaker makes a repair on a statement made in line 2, or rather extends the information concealed in this vernacular ‘any device’. For the listener unfamiliar with this discourse, ‘any device’ could mean as much a water tap as a telephone. However, by excluding the ‘Internet part’ that ‘already’ connects many devices, with their inputs and outputs, such as routers, switches, smart screens, etc., the speaker locates the conversation within the network paradigm, which acts as a background frame for which the ‘Internet part’ acts as a contextualisation cue. Likewise, in line 7, the relationship between the device and the network is made explicit by positioning the network behind the device. Thus a device is seen as a front-runner, the visible part of the network, that not only has a relationship to the network - ‘its impact’ - but also manages its own impact, and that of what it puts through.

The device thus embodies “intelligent vessel-like qualities”. As noted already, when wrestling with the concept of *the thing*, Heidegger (1975:169) used an example of a jug (see section 2.2.2). As with Heidegger’s jug, it is the void inside a device and the performative act of gathering that manifests its ‘thingness’. In the speaker's utterance, we can observe that with a device the conceptual void is for whatever it ‘takes in’ or ‘puts out’ (line 4), and it will be the device’s intelligence and decision-making qualities to manage the world outside (line 12), or the act of it gathering and pouring (like in the case of a jug) that is making it into *the thing.*

However, the device in itself, in a Kantian sense *Das Ding an sich*, or as an object itself[130], may be simply a board, a chip, a network shield with attached sensors hanging from it, a bit of code programmed and uploaded onto that chip by a human, which needs to be powered up and connected to the Internet via an Ethernet cable or wireless card. In the perception of this speaker, a device stands in front of the

130Kant made a distinction between the *thing-in-it-self* or what a thing *really is* and the phenomenological thing. Heidegger’s jug is a relational thing as it gathers other things, whereas Kunt's concept of thing is not relational. (see 'Critique of Pure Reason' (orig 1781, 2017).

network and between the world of material goods and resources (as in line 12). Lines 9 and 10 bring forward the background frame used by the speaker, that of the 'overall system'. While speaking about it in an abstract way, the speaker assumes the existence and presence of some sort of system. This system exists on both sides of the device or on its periphery, at its intake point and at its output point, thus indicating that the background frame is a technological system. However, with the use of the adjective *overall*, the frame is extended into the idea of a total, all-inclusive system in which the digital meets the physical and, subsequently, social space and processes.

The abstract notion of a device containing its meaning in a 'pouring' shapes the concept, and our experience of space. Heidegger suggested that 'Thinging is nearing the world' (1975:178). It is this transition from the bits of technology to a perceivable 'thing', or the becoming of a device, that has occurred, and it becomes evident through spoken language. While the device is nearing the world in the way Neil Gershenfeld (1999) envisaged it, by 'bringing more capabilities closer to people' (1999:245), it is still physically present and technological, as opposed to disappearing into the world or becoming invisible. At this point, however, we might want to ask what these capabilities are that we are attempting to bring closer with the IoT.

4.4.2. The Thing of the Future

> *'Technology progresses along with mankind, and so does the interest in what is technologically more refined; and the idea of perfection is pushed further and further. Hence we always have an open horizon of conceivable improvement to be further pursued.' (Husserl, 1970:25)*

While, for the speaker in Example:6, a device was at the centre of the IoT idea, we learned little about what that "anything" is that the device takes in or puts out. As a technologist, he was primarily concerned with the technological development, and in such a context, the immediate problem would be to resolve the issues concerning the technical role of a device in the process of managing the usage of materials, goods, energy, etc. In contrast, Example:7[131] is a fragment of speech uttered by one of the

131The fragment of utterance is taken from two different takes of the participant's answer to the question: What does the Internet of Things mean to you? The interview was interrupted on day community coordinators (IO_2) who is less involved in the technical development of the project, and whose primary concern is with public engagement and interaction management. As such, he is well articulated in expressing broader visions of what these capabilities are which Gershenfeld foresaw, and which could even be further refined in the Husserlian sense.

Example:7

1. *So the Internet of Things for me means that*
2. *→ We we... will be able to build a world that can actually...*
3. *cater to our needs at any moment, because it senses, it gives us ability...*
4. *the agency to interact with our ...*
5. *with the environment around us at any time, and for anything that we need.*
6. *And yea for me that's...*
7. *→ So I am thinking the Internet itself was an interesting development but it was always contained to... a sort of online world, and with mobile internet it kind of changed...*
8. *but the real change will be in bringing that same capability to the physical ...*
9. *really the physical world em...*
10. *What that would mean to people it is still hard to say*
11. *→ just imagine the place that is always attuned to your needs and is able to adapt itself to to...*
12. *what you are doing and what you need.*
13. *That's interesting...*
14. *and can be very powerful.*

Take two of the interview.

15. *So I am seeing the Internet of Things as a a...*
16. *a place ....liberating in a sense ... em...because*
17. *it will help us ...to be more ...*
18. *like liberating in a sense that we will be able to do things that we care about and not have to worry about...em...*
19. *everything else ...basically.*
20. *So that's how I am seeing it.*

Q: Like managing the world around us? (asked by interviewer)

21. *Yea, so that the world...*
22. *not necessarily, not necessarily managing it in a sense, but also ...*
23. *So the Internet of Things could be an environment that gets out of your way. I am thinking. (3)*

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one, and resumed on day two with the same question.

24. *What I mean with that is that...*
25. *Because the <u>environment would be</u>, you know*
26. *<u>could be attune to you</u> and <u>could have a capability to to to facilitate you</u> with ...*
27. *<u>whatever you need=</u>*
28. *=whatever <u>functionality</u> you need, whatever <u>information</u> you need*
29. *<u>at any given moment</u>*
30. *that means that*
31. *<u>we can be more free flowing</u> in a sense...em...(5)*
32. *we will get <u>detached from screens</u> basically and*
33. *<u>start moving around</u> more...*

For speaker IO_2 (Example:7), the vision of the Internet of Things is located somewhere in a built environment. In lines 2-5 the speaker employs the depiction of the future scenario as his framing device, and uses a passive voice as marked by the referential indexical we/us/our. The use of ‘we’ here is signalling a combination of both the inclusive ‘we’, in which the speaker sees himself as part of something, and the generic third person ‘we’, or informal ‘you’ that is often used in the scientific field and futuristic literature, referring to ‘ the broader human race, a generation, people. However, by entering a claim on behalf of ‘we’, the speaker is also creating a specific form of collective identity that is constructed by the collective choice made by a course of action. Such use of pronouns and framing devices gives us some indication of the primary framework employed here, the underlying belief in one world, one human race/civilisation engaged in a modernist project, and the inevitability of a techno-social future and a framework for collective decisions to foster actions towards the bettering of the common world.

The use of the transitive verb phrase ‘will be able to build’ not only takes us into that future frame, pointing away from the speaker’s present, but also points to some acquired ability or technological opening that has enabled this future vision of the world. While the indexical ‘that’ refers to ‘the world we will be able to build’, the use of the adverb ‘actually’ reveals some insight into the diagnostic framing used here. The grammatical use of the word ‘actually’ is not clear. It could both be used in the sense of ‘in fact’, or as an expression of opinion as the speaker makes a significant pause after this line of utterance. However, it is clear that the speaker is placing emphasis on something that is hard to believe in, and is contradictory to the place and time he is currently speaking from. The mental frame at work here is thus a diagnosis of the world that does not sense or cater to or empower us with the agency to interact.

In line 3, the essential characteristic of that future world, envisaged by the speaker and marked with indexical ‘it’, is revealed – it is the ability to sense. The ‘world’ that can act, as an active agent, is, at the same time, the ‘world’ that will give us (humans) the ability and agency to interact with our environment. Here, the clarity between two domains of space becomes apparent. The mass of that world ‘we will build’ will help us to interact with the mass or the space of the environment around us, thus making a distance and distinction between ‘the world we will build’ and that environment around us.

In lines 7-9, the speaker shifts the spatiotemporal framing to here and now with the referential indexical ‘I’ and a verb in the present continuous. The association is made between the development of the Internet and the future IoT, where the development of the Internet, in the past tense, is described as ‘interesting’ followed by ‘but it was always contained to ... {the} sort of, online world’. Here, a difference is made between the perceptions of the two spatial paradigms, the Internet and ‘online world’, where the former is contained by the latter in a confined space. In line 8, the speaker returns to the main issue frame in a foreground. By combining the notion of the Internet with that of the physical world (by the use of prognostic framing), the anticipation of a real change is formed.

Similarly, by means of future framing, the notion of confinement to the online world and the ‘real’ promise of the IoT are reiterated in lines 16-19. While the online world is seen as space, the IoT is perceived as a place in a physical world. Likewise, the real change that will come is perceived as the total opposite to confinement, and is associated with the catchword ‘liberating’. In line 17, that place of the IoT is seen as a subject, with its agency (marked by ‘it’) that will help ‘us’ to get rid of our chains, i.e. the place with the tables and screens we must sit by (see lines 32-33).

In lines 11 and 12, the speaker once more uses the depiction of a different point in time and continues to create the future image of the IoT world. Signed with the marker ‘just imagine’, the frame is brought to life. To describe that future, the speaker uses two metaphors of place. The first metaphor refers to a place that is ‘attuned’ to the needs of the human subject. It is adjusting in response to a movement of 'our needs'. It is ‘our needs’ that it is tuning into and listening to. It is an environment that follows us. It is the listener. The adverb ‘always’ implies that interactivity between that environment and the human body is on-going. In a second iteration of the same metaphor of attuning (lines 23-29), the physical relationship appears again. It is reimagined through a surrounding environment that ‘gets out of your way’ (line 23).

The second metaphor (line 11) carries an allusion to a biological, an organism-like feature, that ‘is able to adjust itself’ by conforming to a new or changing condition. As with the previous examples, in relation to devices, the vision of the IoT here is perceived as a sort of living and breathing organism that is able to adapt, listen into, move out of the way of, and facilitate us. When asked to specify if it is the management of the world that brings meaning to the IoT, the speaker hesitates. Initially agreeing with such an approach (line 21), he later (line 22) initiates the repair, which is then carried out in line 23. Thus, the concept of the IoT as a manager of our lives and the world around us is not satisfactory here. It might be able to manage itself; however, in relation to us, it seems that the interaction is presumed to be much less fixed.

As we have seen so far, the relations between this morphed space and human beings are envisaged as on-going, interactive and, in some sense, ‘liberating’. Lines 18 and 26-29 provide us with the interpretation of what is meant by ‘liberating’. In line 18, the focus is shifted from a place (line 16) as a liberating acting subject to a human agency. Enabled by this new relationship, humans will be able to do what they want or do ‘what we care about’, with no concerns, ‘free flowing’, ‘detached from the screens’ and ‘moving around more’ (lines 32-31). Lines 27-28 also gives us a glimpse into what possible ‘needs’ the IoT morph could facilitate: functionality and information. By naming these two essentials, the speaker not only indicates their perceived values in our time, but also conveys the presence of a master frame - the rationality of the information society.

Husserl, early on in his introduction to phenomenological philosophy, evaluated the nature of modern rationality, its desire for objectivity and the inescapable evolvement of the world, in which all things are bound a priori by what he called an overall style of the world.

> *However, we might change the world in imagination or represent to ourselves the future course of the world, unknown to us, in terms of its possibilities, 'as it might be', we necessarily represent it according to the style in which we have, and up to now have had, the world. (Husserl, 1970:31)*

In an information society, information dominates not only all aspects of production, of wealth, goods and services, but also our decision-making processes and the ways we manage our everyday lives. Paraphrasing Husserl, it is this presence of the intuitively-given surrounding world of the information society that makes possible any hypotheses and predictions about the unknowns of its present and its future. Simultaneously, it is at this point in time and space that the desire to accumulate more information about that very intuitable world around us is created. While Husserl, rather poetically, described the extensions of each body that makes up the total infinite extension of the world, and subsequently the ideal form to master through construction, it seems that it is just about now that we are approaching the dawn of this construction.

4.4.3. Sensors as Extensions

As previously discussed, much of the Internet of Things discourse so far has been driven by the need to identify consumer products, objects, and things in general. However, to achieve the interconnectivity of the physical world and to achieve the intelligence of that world envisaged in the example above, the simple identity data of a device or thing would not be sufficient. As we will see in the following examples, it is perceived as common sense that the attention has to be turned to the development of sensing devices and sensors themselves. Or in other words, sensors are placed at the heart of the next stage of the construction.

Example:8

1. *Currently <u>it's about sensors</u>,*
2. *Because, if you have a thing, <u>its needs to communicate something</u>*
3. *And if it...*
4. *If it does not have any <u>changing input</u> <u>it is not very interesting</u> to <u>listen to</u>.*
5. *So ….((shaking head fro right to left))*
6. *I cannot think of anything that...*
7. *Only <u>things</u> that change*
8. *<u>is interesting to publish</u> <u>to the network</u>.*
9. *Or <u>things that can be changed</u> like your toaster*
10. *if you want to switch it on <u>from your home</u>, <u>from your work</u> what ever.*
11. *That's interesting.*
12. *So things that can change, machines that can change, cats, animals.*

The utterance here is a response to the interviewer's observation that much of the current development around citizen science in the field of the Internet of Things is based on the development of sensor devices. By employing both the citizen science and the IoT meta-frames, with the referential indexical 'it' in line 1, the speaker not only signals his confidence in the events in his community but his wider knowledge of the discourse. Furthermore, with the adverb 'currently', the speaker signals his perception that such developments are time-bound. In line 2, the prognostic framing is employed to state what is perceived as obvious: in this particular collective action framework, the fact that any *thing* 'needs to communicate something'. In the following three lines, the reiteration of the same thought, through the diagnostic framework, is made by assigning already discussed inputs and outputs to the things, thus making them relevant to the larger organisational framework. In the same way as in previous examples, in line 4 the metaphor of listening is applied in the context of a device's inputs and outputs.

The importance and value here is attributed to the changing quality of inputs/outputs, and thus the movement, and subsequently to the information or data flow. While the 'need to communicate' might suggest the pure signal of 'send and receive' functionality, frequently changing inputs and outputs suggest flow or stream like qualities that are communicated over the network (line 8). In lines 7 and 8, through the use of a metaphor, the spatial configuration between dispersed things in the plural and the network in the singular are established. It is, however, not the things that get pushed to the network but the data from these things. The morphing of these two notions could be seen as a vernacular as much as a perception of the ‘things that change’; the data, i.e. what the thing produces, is perceived to be part of the being (or in Husserl’s term the *plena*[132]) of the thing in itself.

The perception of spatial configurations is unveiled by the movement of data discussed (line 8) in terms of a unidirectional flow, i.e. things published on a network thus connecting the physical space to cyberspace. Meanwhile, in lines 9 and 10, when the talk is about switching the thing on and off, the movement appears to be in the opposite direction, from the physical place, home or work, to the ‘toaster’. Both places, the place of the toaster and the place of the human, at home or at work, are perceived to be in the realm of physical space, while the connectivity provided by the virtual space is unmentioned, taken for granted or, in other words, made invisible by the primary framework–network/connected world paradigm.

In the above example, the sensor is perceived for what it is: a piece of technology, a practical tool, the application of which ensures a change in a device’s inputs and outputs or, in other words, the sensor’s primary functionality. Example:9, however, through a wider interpretation of the role that sensor technology performs in a social context, broadens the perception of sensor application within this community of practice. It provides us with some openings to assess the complexity involved, not only in the application of sensors but also in the wider challenges associated with the measurement of that very intuitive world they assume to measure.

Example:9

1. *I think there is a lot of interest in sensors because they very hard to ... am*
2. *they are actually very hard to hack.*
3. *We worked with em... x, an artist, in London at (company X) on em...*
4. *basically hacking a CO sensor...for everyday levels*
5. *And it turned out to be a total nightmare.*
6. *Because those types of sensors are actually designed by the industry for industrial purposes where they are looking at levels of em...*
7. *CO that are very different from what we experience on a daily level.*
8. *They are looking at industrial use of ...*

132Husserl identified *plena* as: 'the “specific” sense-qualities - which concretely fill out the spatiotemporal shape-aspects of the world of bodies' or, in other words, the 'sensible qualities of bodies'. (Husserl, 1970:33-37)

9. *industrial sensing as it were.*
10. *So ...they are hard to hack, but they are also kind of our ears and our eyes and our fingers into the world, into this invisible world of em...*
11. *whether its air quality, such as, what X is been working on for Pachube.*
12. *And em...*
13. *whether its CO, NO_2...*
14. *these are all things we can feel with our bodies,*
15. *so they are kind of our little extensions and we are trying to get into the world.*
16. *You know, noise levels, things that actually affect us quite a lot, that affect our mood, you know.*
17. *If you are, kind of, ...in a constantly busy place all the time, you get a headache...em...*
18. *So being able to have something that kind of knows*
19. *'wow, do you want to go somewhere quite now? Might be good for you'*
20. *I think that's driving a lot of ...*
21. *thinking and lot of innovation, this idea that we can extend…*
22. *you know...its not quite a cyberspace dream of the nineties but em...*
23. *it is getting there very slowly.*
24. *Being able to kind of listening in for things.*

As in Example:8, this utterance is a response to the question about the growing interest in sensor technologies; consequently, the existential *there* points towards the collective action framework. The task here is diagnostic. Thus, what seems to be the issue or problem here is the *growing interest*, which is attributed to the nature of the subject matter, in the foreground – sensors, and the fact that they 'are hard to hack'. The use of the vernacular, such as a *hack*, brings attention back to the meta-frame.[133] *Hack* here implies the positive meaning of the word in a context such as hackdays and hackathons, currently widely used terms in contexts of technological innovation, start-up culture and technology-related businesses. A hacker in this context is seen as one driven by the challenge (as in Example:5) that is presented by one or another technology, rather than by any other personal belief or even darker matters of the

133Previously, in the interview when describing his role as creative technologist within the advertising industry, the speaker was asked if such position could qualify as a *hack* in terms of breaking the ordinary. to which speaker responded: 'I think the main differentiator, what makes hacking so special, in a way, is that more often than not it is powered by curiosity. It's entirely powered by someone's need to scratch an itch, the requirement for technical ability there is none. /-/I don't think we should professionalise the term hacking because then it puts commercial pressure on that term, and it puts pressure in a way that industry would not know how to react to, you would end up with people under business cuts. I mean, you do have that, you have people using *hackers* as a professional term. More often in our industry that means the darker side of hacking because it is also a term that gets used in the press, whereas the hackday always sounds like fun, sounds amazing and engaging, lots of people there. And I think that whimsy, in a way this (makes a hand movement towards room) group of people understands what hacker is, it is good. I don't think we should take it out of that box.'

hacking culture.

In lines 3-5 the speaker, by evoking an experiential example, tactically employs numerous framing devices, e.g. storytelling, shifts to a different point in time, and image-making in order to ground his previous strong statement made in line 2. The use of the passive indexical ‘we’ announces more distributed knowledge, experience and collaborative practice. The framework applied here tells the story not only in the foreground, i.e. how difficult it is to hack a CO sensor, but also that the speaker worked at company *X* that collaborated with an artist *Y* on the development of a technologically challenging project. In line 5, the problem is diagnosed again, this time with the use of the strong image created by the common vernacular - the depiction of a nightmare[134].

In the following four lines, the speaker reiterates his strong statement of associating ‘hacking a sensor’ with that of a 'nightmare’, and with it, the change of framework can be observed. Here we can observe how diagnostic framing corresponds with prognostic framing (Benford and Snow, 2000). The problem here is attributed to the fact that the sensors are designed for industrial use or industrial sensing, whereas the citizen science or art hacks want to use them for everyday sensing; thus, they want to use them for what they are not intended. This is an excellent example of a collective action frame that not only reveals the collective action frame at work, through the identification of an opponent or the other against which the perception of the collective is situated, but also works as identity frame boundaries (Hunt et al., 1994). The collective here is identified as not being a part of the industry, and not being interested in the industrial use of the sensors. Rather, it seeks to find an innovative use for the sensors or to apply them in a new, yet unknown, situation. Through this collective action frame, the idea of technological appropriation is also highlighted as it is perceived as one of the significant aspects of the group's identity.

To overcome the aroused negativity brought about by the disclosure of problems related to sensor hacking and the hardship that entails, the speaker swiftly adjusts to the next action frame. From lines 10 - 21, with the help of positive metaphors, visual

134From my notes on ethnograpic observation 12.02.18.: Asked about the sensors, the speaker moved his hands in the air and uttered something like ‘that’s ...’, ‘don’t ask me about sensors’. He was smiling, and I could identify it as an insider joke.

image creation and exemplars, motivational framing is activated to once again elucidate the rationale for the engagement. By drawing parallels between the sensors and human sensory body parts, the image of bodily extensions is created (lines 10-15). The idea of extensions here is not that of Haraway's cyborg that alters the whole perception of the being and its identity, but rather echoes Husserl's understanding of bodies of the empirical-intuitable world, which he rationalised in following:

> *Each body has – abstractly speaking – an extension of its own and that all these extensions are yet shapes of the one total infinite extension of the world. (Husserl, 1970:35)*

In lines 10 and 15 the speaker points towards this 'invisible world' outside of our bodies, which we are 'trying to get into', as though it is a space out there but we are not there yet. In line 14, it is acknowledged that we can feel 'all things' that are out there, such as CO, NO_2 etc., with our bodies, but for some reason we are not there yet or, in other words, we are not aware of what we feel. This could be due to the invisibility of these things, the distrust in the body's sensory systems, or because we have never had the technological potential for building these extensions. The speaker later confirms his perception that it is the latter by expressing the desire to 'extend into the world' with the current drives for innovation in the field of design and technology.

The practical exemplar of interaction between the world out there and the body is employed (line 16-19) to make the motivational framing more specific. By using the informal conversational dialogue marker 'you know', the speaker familiarises the subject and chooses the issue of inadequate 'noise levels' as the most graspable exemplar for a problem we have with being in the world. Here, numerous mental frames are also at work. The chosen example not only relates to the issues in the foreground of this conversation, i.e. things we could use the sensors for, but also reveals the issues working in the background, such as the noisy and constantly busy place we live in, most likely describing urban environments, and the notion that the high levels of noise can affect our moods and give us headaches.

While lines 16-17 are diagnostic framings, lines 18-19 switch to prognostic framing in which the remedies proposed are specific to this community of practice. What in other participant utterances emerged as a device or an intelligent thing, here it is referred to as ‘something’ that ‘kind of knows’ what is going on out there, in the world, and talks back to us (signalled by the form of constructed dialogue in line 19): the sensing, knowing, feedbacking, advising thing that will look out for us. As in examples 6 and 3, the speaker here shares this collective belief or viewpoint that there is agreement on what the next ‘conceivable improvement’ is: sensory perception, i.e. what can be technologically more refined, in the form of sensor extensions; and what the possible solutions are, in the form of technological innovation. Likewise, as seen in Example:3, here too (line 18) the speaker assigns the agency of power to that something (the thing in 'becoming') by trusting it to ‘know’ when it is too noisy for us and when we need to seek refuge. However, though the same thought is reiterated (line 24), the use of the passive voice points to a sort of shared agency where humans are empowered by the knowing, provided by that something, and enabled to ‘listen in for things’ that most likely were previously unreachable.

Nevertheless, as it has been observed in this example, there are also other shared agreements, for example on identified problems with the sensors, that are associated here with the metaphor of ‘nightmare’. As highlighted by the above utterance, the sensors used by the developers in this group and other citizen science projects are made for industrial sensing and are not fit for measuring slight changes, for example in air quality, occurring on everyday levels. Another participant, IC_4 in Example:10, also highlights the same issue with sensor quality:

Example:10

1. *there is a huge number of concerns that can be met by saying:*
2. *‘well, I am gonna do it myself’...*
3. *and in that sense... you know...*
4. *<u>we realised</u>...*
5. *one...*
6. *you can go to talk today and realise...*
7. *<u>how much challenge that is to do it yourself</u> that, you know...*
8. *<u>they realised</u> that*
9. *well, <u>building a really good sensor is gonna cost you</u>...you know...*
10. *a lot of money.*

11. *and this 10000 or 15000 or 16000$ sensor, you know...*
12. *package is not totally unjustified in <u>the amount of engineering</u> that goes behind it.*
13. *But the same time <u>we don't know processes</u> that happen.*

As can be observed in this example, the mental framing here is that of a 'do it yourself' culture, and the approach, with which the speaker is identifying himself (line 4; 6), is that of the group of his collaborators (line 4) and other presenters in the summit (line 8). In lines 4-12, task framing is utilised while detecting common challenges: 'the amount of engineering that goes behind' (line 12) building a 'really good sensor' (line 9) and the cost associated with that (line 11). Line 13 returns to motivational framing and the reasoning behind the group's disengagement with these 'really good sensors'. Here the DiY and open source cultures is identified with the mental frame of the collective belief in open technology rather than being justified in terms of a cost[135].

The 'nightmares', talked about in Example:9 and associated with sensor hacking in Example:10, are only partly associated with the cheapness of one or other sensors available on the market. It is rather their sensitivity, the sensing values of their output, and matters of calibration that not only define their price, but also define the complexity they impose to their understanding and interpretation of the overall system. The calibration or accuracy of sensors, and subsequently the data they deliver, will define any interpretation and, consequently, knowledge built on that data. In the following, we will observe how the approach to calibration taken by this community is developed and justified, and what challenges that implies.

4.4.4. The Problem of Calibration

[But] through Galileo's mathematization of nature, nature itself is idealised under the guidance of the new mathematics; nature itself becomes – to express it in a modern way – a mathematical manifold [Mannigfaltigkeit] (Husserl, 1970:23)

135From ethnographic notes: Aim: the final cost of the air quality egg device should be less than or about 50$, and should have at least four sensors on it. From the interview with participant (ICI7): 'I didn't know much about sensors themselves. And siting around here I am finding out more about them, about the ones that are being used, and these are cheap enough ones, and also about the ones which are not cheap enough and therefore not being used, but should be, something we need to look at more.'

For Husserl, early in the twentieth century, the problem of abstraction, through the art of measurement, lay at the heart of what he saw as the crisis of European sciences. In the introduction of his contemplation on the crisis of scientific approach[136], he made a point that from the times of Galileo and even before, the achievement of 'true' knowledge and 'objective being in the world' has meant an on-going overcoming of the relativity of the subjective interpretation of the empirically intuitive world, and subsequently 'constantly increasing approximation', through idealising and mathematisation. However, for Galileo in his time, this approach (then only practised in the field of geometry) had its flaws when it came to the measurement of specific sense-qualities of the world, or what Husserl called the *plena* of the world. In abstracting this sense-quality aspect of the world, Galileo mastered indirect mathematisation and apprehended the meaning of causality and its role in the interrelationships between shape and *plena*, and consequently the basic principle of observer-relativity.

Five hundred years later, the developers in this community of practice, working on measurements of air quality, again find themselves negotiating their path to objectified knowledge, thus continuing the never perfect art of measuring. As we can observe in the following utterance in Example:11, the speaker (IC_4) is very casual about the validity of data produced by the first prototypes of the Air Quality Egg device, deployed during the Citizens Cyberscience Summit workshop.

Example:11

1. *its getting information, whether that information is pertinent that's ...*
2. *that's going to be a long haul of this and...*
3. *I think that there is lot more presentations today, specifically about*
4. *validating this data scientifically and validating under the research and then also validating it personally.*
5. *And I think that ...*
6. *the personal approach is gonna be much more successful,*
7. *I feel, right away, then ...then a research approach, I think...that*
8. *It…it hopefully won't trigger kind of a...a...a...*
9. *cried wolf scenario, where we stand up and yell about air quality when ...*
10. *we don't really have a problem but ...*
11. *I am hoping we are on a right track that...*

136'Discovery is really a mixture of instinct and method,' wrote Husserl in *The Crises of European Sciences* when analysing the Galilean idea of universal physics. (Husserl, 1970:40)

12. *Even if our data is not valid scientifically or in that ...*
13. *technical ...direction,*
14. *I hope that we get the right information to say: there needs to be more study.*
15. *That air quality sensors like this really can be em...*
16. *go to for application of real high-end sensors, I mean...*
17. *The government has picked places to put sensors, but what if we can say*
18. *"well, there is real pockets here that you need to be careful of",*
19. *or "right around the school there is this traffic intersection that you know...*
20. *we have really weird readings and that we have changed our sensor ... times and still getting really weird readings", you know –*
21. *further investigation!*
22. *And that's a win right there...you know...*
23. *Whether or not... the data is great or not*
24. *I don't really care.*

The indexical 'its' in line 1 refers to the foreground framing, the progress in the development of the Air Quality Egg, discussed before this utterance. The indexical 'that' in the second part of the sentence (line 1) refers to the previous part of the sentence, i.e. the information received from the Air Quality Egg device. The following 'that' in 'is going to be a long haul' (line 2) refers to the discussion about whether the information received is valid, while 'this' refers to the upcoming sentence were the specificities of validity and the context of discussion are examined.

The prognostic framing here works within the motivation framing, pointing towards a kind of acceptance of the ongoing process of negation that is an integral part of the project itself. In lines 3-7, framing devices of exemplars and time shifts are utilised. The speaker turns to the concreteness of current space-time and the talks that are happening during the summit, where discussions about the data validity of this and other citizen science projects are taking place. Three validation approaches belonging to the mental frame of citizen science are presented: scientific, research and personal. Here, the presence of another mental frames surfaces as the speaker presumes that his perception of what classifies as research or personal approach is commonly agreed upon. In line 5, the speaker announces with a strong indexical 'I think' that the personal approach will be more successful than that of a research approach. By aligning himself with the personal approach and by expressing such certainty of its success, he points towards the presence of a primary frame that could be identified here as a political form of assembly, identified with the global citizens movement[137] and the recursive public[138], encompassing both the open source and citizen forms of organisational frameworks.

The reasoning for his strong statement and specificities of the primary framework become more apparent in lines 12-23 when the speaker employs the depiction of possible scenarios, which does not really explain the personal approach any further, but does, however, illustrate the situation where citizen sensors could be distributed more densely and located on a much more local level, in locations that might matter personally (lines 18-20). The boundary framing is activated in line 17 in which the collective action frame of citizen science is positioned in opposition to a government and its sensor distribution. Likewise, the boundaries and distance are drawn between ‘air quality sensors like this’ (line 15), with ‘this’ pointing towards the sensors developed within this group, and ‘real high-end sensors’ (line 16) identified as ones been used by the government or industry – or in other words the other, outside the collective action frame.

The key to the understanding of data validation processes employed by this group is found in lines 12-14. In line 12, the speaker acknowledges the fact that it could be that the data, identified as ‘our data’, might not be scientifically valid. It is not, however, clear if the possessive adjective ‘our’ in front of ‘data’ refers to a particular data generated by the Air Quality Egg device, or it represents the broader, possibly DIY or open source community, approach to data validation. Nevertheless, as the statement is made in the context of the organisational framework of this particular community, I would suggest that ‘our’ here refers to the approach taken by this exact community of practice that clusters around the Pachube platform and its satellite projects.

137For more on the global citizens movement see: http://en.wikipedia.org/wiki/Global_citizens_movement

138See Kelty (2008): “a public that is vitally concerned with the material and practical maintenance and modification of the technical, legal, practical, and conceptual means of its own existence as a public; it is a collective independent of other forms of constituted power and is capable of speaking to existing forms of power through the production of actually existing alternatives” (Kelty, 2008:28).

From lines 12-14, we can also learn that the nature of this inadequacy, in scientific terms, is to do with a technical issue or, as we learned previously, due to the shortcomings of the sensors themselves. However, the validity of ‘our data’ is explained in terms of information. Thus the difference between the data and information is made explicit. As further elaborated in line 20, the information is created by the changing values of the sensor data, while calibration is done through the comparison of different sensor data. An interesting peculiarity pointing towards the collective vernacular can be observed in line 22, where the speaker identifies the value of acquired information via comparison of data and its local meaning with the ‘win, win’ situation. This not only suggests that the identity of the group is sustained in dialectic opposition, but also notes the importance attributed to playfulness, highlighted earlier.

Other participants also raised the issue of calibration by means of comparison. In the following Example:12, participant ICI_6, while being optimistic about the community’s involvement in the development of sensing devices, expresses her deep concern about the approaches taken regarding the calibration process.

Example:12

1. *but I am concerned with ....*
2. *actually at the mo(ment)...the issue ...*
3. *<u>the issue there</u> is <u>one of calibration</u>.*
4. *It's no good saying <u>it's worth</u>, <u>it's better</u>... <u>worth or better than what</u>?!*
5. *And that’s where the issue comes from.*

In lines 2 and 3, the speaker makes a repair of the utterance made in line 1 in which she expressed concern. She replaces her ‘concern’ with the ‘issue . . . of calibration’ that she is concerned with at this current stage of the development, marked by ‘at the mo(ment)’. The issue is elaborated in line 4 as a method of comparison. What is not clear is what data gets compared with what.

The issue related to calibration could be temporary, and might not qualify as distinctive or exclusive to this particular community of practice. However, as almost all interviewed participants commented on this issue, it could be assumed that it forms an important part of the very identity of this group: the mastering of the art of measuring. The following Example:13 illustrates well the length and the complexity of the multiple issues involved when an attempt is made to compare two or more specific sense-qualities, or unlike things, or two sets of technically inaccurate data.

Example:13

1. *I do use other peoples data and they use mine. Em...*
2. *as a... you know, to compare...*
3. *but there is a problem with that, which is that at the moment*
4. *there is no calibration of buildings, em..*
5. *other than it's a very crude building codes,*
6. *which are not very useful.*
7. *And anyway, I even don't know what is the building code of my building is,*
8. *because you can't...*
9. *you can't do that yourself. That's a ...*
10. *You have to pay to have that done, so...*
11. *I sort of don't care because it is not precision information, so...*
12. *What would change that ...*
13. *and again you could do around Pachube, or you could do that as separate initiative...*
14. *would be to calibrate buildings, so that...*
15. *you say: ok mine is five bedroom family house in a suburbs and*
16. *I find comparing to somebody else*
17. *either I want to compare to with almost identical place or*
18. *I want to have some kind of rating system that I can fracture it,*
19. *so then I know em...how we doing relatively.*
20. *If we are having like an energy competition...*
21. *So coming back to my colleague and I, we are having this completion to see how much*
22. *energy we can save...*
23. *that was a little bit easier for us because I know, you know...*
24. *I go to his house, I know the house. He knows mine.*
25. *So when we comparing, we know how to make that comparison.*
26. *and I think, that's a problem with shared data.*
27. *Shared data is great but ...*
28. *kilowatts per house, or something...*
29. *some measure like that is kind of not useful.*
30. *You need to have some kind of calibration system,*
31. *some kind of profiling system in order to be able to make comparisons.*
32. *Say and if you are talking about health, lets say.*
33. *Say we compare my daughter and I, right,*
34. *she is training for a marathon and I would die...*
35. *if I go ...and if I would try and do one((LG)).*
36. *So, you know, you can't...*
37. *however, we... I might I might be trying harder than her*
38. *in a relative sense and should be getting brownie points for that,*
39. *if we are having a competition.*

40. *So all those kind of* *calibration things*, *calibration of measurements and also*
41. *comparability* *between unlike things* *you are measuring*
42. *that's all* *yet to be done*.

In Example:13, utterances are made in response to the question about the collaborative aspects opened up by shared platforms such as Pachube. The interviewer asked if participant ICI_7 had some data on this system and whether he had some knowledge of other community members with similar data sets. This lengthy response, while confirming the participant's engagement with the other people's data on this data-sharing platform, is effectively saying that while the theory of shared data is great, the practicality of it is currently very problematic due to calibration.

In line 1, the speaker reiterates the question in his own words, affirming his usage of other people's data for reasons of comparison (line 2). In lines 3-11 the speaker shifts the focus to a mental frame that works here as a background for an immediate issue frame, which could be a derivative of the master frame – legislative system of the build environments, its historic materiality and state or council management systems. The task here is to make a diagnostic assessment of the context for the foreground framing, i.e. lack of 'calibration of building' (line 4), 'very crude building codes' (line 5) that 'can't be done by yourself' (line 9) and 'must be paid to be done' (line 10), and finally no one really being responsible to resolve this (lines 10-12).

The core issue, revealed in lines 23-29 as the problem with shared data and unrelated values, is seen as a temporal issue (line 3), something we have already observed in perceptions of other participants in relation to calibration. This suggests a notion of the problem's temporality and the belief that it will be overcome. The same confidence is expressed here even when the diagnostic framing leads toward the problem, beyond the direct powers of an individual or the group. This might be explained by a larger master frame being at work here, that of citizenship, identified by scholars previously (Berger et al., 1972; Statham and Mynott, 2002; Koenig, 2004).

Here it can be identified by the way the speaker employs prognostic framing (lines 13-19) to overcome different complex issues concerning building calibration. The solution is sought by applying methods (line 13) characteristic of ‘do it yourself’ or open source culture, identified with this community of practice or, more lately, by the crowdsourcing approaches of citizen science, such as to ‘create some initiatives’ or use existing ones (line 13), around which people could participate by describing their own houses for common purpose, for example. In such a scenario, the measurements could be done on the basis of relative value comparison (line 19).

In lines 20 to 25, the speaker employs an exemplar that refers to a story he shared earlier on in the interview. The story involved a competition between the speaker and his colleague over who would save more energy in a set period of time. While the speaker turned to the installation of an energy monitoring system, his colleague applied analogue methods such as checking the meters and writing the values down with pen and paper. The competition not only saved the speaker money but also taught him valuable lessons through doing, or praxis. The speaker admitted learning how his heater works. He also learned how to construct graphs from his data streams, and came to the realisation that the biggest saving was done not by automation but rather by remembering to switch off the lights when not needed.

In Example:13 (line 25), the speaker reveals one of the important elements necessary for any calibration based on comparison – to know the relevant elements involved in the comparison. Here, knowing is associated with that of physical experience, of being in the house (line 25 ‘I go to his house’); that would imply knowing all the variables such as how many rooms are in the house, where it is located, when it had been built, etc. (line 15). After reiterating the problem in lines 30-31, where he introduces a new term ‘profiling system’, the speaker turns to another example that illustrates the shared data and calibration problem, this time in the health sector (line 32). Here, the speaker not only appropriates a framing device to reach out to his audience and explain the meaning of ‘profiling system’, he also introduces another mental frame – data mining across many sectors and fields of life.

In this example (33-39), the speaker introduces the comparison between himself and his daughter competing to run a marathon. In lines 34-35, the speaker presents two very different states one would need to compare. The daughter, who is training, and his, that he 'would die', implying his age, his identity as a geek sitting down a lot, and the fact that he has never even considered running a marathon, marked with 'if I would try and do one' (line 35). Likewise, the utterance is expressed with a disbelieving smile and followed by humble laughter. The other variable is introduced in line 37 – he 'might be trying harder'- followed by another in line 38 when he talks of the 'brownie points' he should receive for even trying, bringing to the foreground the perception of self as one that simply would never consider running, as well as the social mental frame of normality with regards to age and physical activity.

Lines 40-41 bring the issue frame into the foreground again by reiterating the key problem with shared data and calibration, that of heterogeneity ingrained in the nature of things, i.e. measurements and standards. By choosing the solution to the problem, as he did in lines 12-13, the speaker aligned himself with the previous speaker of the utterance in Example:12. Both speakers chose to take a personal approach to data tagging, conducted in a framework of responsible citizenship. This approach is celebrated by all members of this community (observed during my study), and to an extent defines the core method of calibration applied in this community of practice.

4.5. Conclusion

By looking at the linguistic markers, assemblies and vernaculars utilised by speakers in this community of practice, this part of the study aimed to identify the perceptual frameworks informing their practice, and the subsequent broader development of the Internet of Things. I began the analysis with an examination of the speakers' motives for participation, and argued that frame analysis of their speech acts provides not only clear categories for their reasoning but also gives an insight into the structure of community formation itself. For example, while much of this community's activity could be characterised in terms of a community of practice, there are visible indicators of broader social systems involving other structures, projects and associations. The alignment with contexts such as open source movements, DIY culture and citizen science were often evoked. Speakers' use of the reference frames also reveals the inner workings of the community; for example, the role community organisers play with the overall structure or that, at times, its formation might be more in line with a network-like structure. However while networks involve connections, it is the identification and commitment with the domain that in this case, I argue, following Wenger (2009), emphasises the identity of a community. The data also suggests the participants' awareness of norms, values, and expectations identified within this community and its boundaries, and its relation to broader IoT discourse, as presented by their communicative competencies and use of domain-related vernaculars.

As was observed, in the speakers' perceptions, there is growing importance assigned to the role played by a device in the reorientation of power and knowledge, while the position of the things is still discussed in the future tense as imaginary of connected environments. However, while the devices are perceived as physical extensions out there, doing their thing, it is through the relations they have with humans that provides meaning, or even empowerment, for human-to-human relations. Furthermore, as was observed, while the role played by the device in spatial reconfiguration is becoming more prominent, the perception of the underlying network is diminishing.

The key objectives of this community have been identified as to further their connectivity with the physical world and to sustain the identity of a 'recursive public'. In maintaining and modifying the technical and conceptual means of this next stage of development in a public framework, the methods embraced are often playful and sustained in constant negotiation. While often employing and modifying cheap and available technologies, the art of measurement is furthered by negotiating through both subjective and objective viewpoints. Likewise, the obstacles presented by chosen methods are seen as temporary, and as such believed to be defeated by the wider distribution of technical devices, and citizen participation in creating thicker layers of subjective perspectives.

The linguistic analysis of the speakers' utterances, I argue, has made apparent that much of what could be identified as the space of the IoT is produced by perceptions and speech. Likewise, the different spatialities are continuously navigated and called upon through the change of frames and framing devices. The place in cyberspace is called upon in a similar manner, as a place in a physical world, like in the example of 'Pachube being the only place to go'. With the application of sensing devices as extensions, it can also be observed that the perception of what is getting extended is rather contradictory. For some, they are extensions of a body, while for others they are perceived as extensions of the world out there. Thus, at this stage of the research, I would conclude that, under the emerging paradigm of the IoT, perceptions of both the physical world and cyberspace are undergoing an enduring transformation.

As highlighted, Husserl, and his critique of the nature of the mathematical universe and modern science, provides some insight into the importance of considering human perceptions and the relational nature we have with the world, one that is not uniform but rather dynamic and constantly reshaped. As such, I would argue, the arrival of logobjects, or intelligent sensing devices, are perceived as a final attempt to mathematise the specifically sensible qualities of bodies, or what Husserl called *plena*, and the states of their every change. The process of constructing this layer of sensing extensions is defined by the methods and instincts used in creating these very devices, as well as an understanding of what is constituted as exactness in the measuring process. As Husserl has argued, the art of measuring 'is a method for improving [this very] method, again and again, through the invention of ever new technical means' (Husserl, 1970:41). Each stage of this *infinitum* requires the sense of approximation. Each approximation will affect our perception of what is out there and what is measured. Thus, understanding the processes and intuitions governing the current construction of extended spatiality should help us better navigate the space in the future.

5

COLLECTIVE SOCIAL PRACTICE: THE THING AND THE NETWORK

5.1. Introduction

The first part of this study involved mapping the shape of the community and perceptions of its members through the linguistic analysis of speech. The second part will turn to an ethnographic examination of this community of practice as they embarked on the development of the Air Quality Egg project to foster public conversation about air quality. This part will explore how, through a process of collaborative production, they created an opportunity for a public discourse of meanings created by such devices and through that, the social awareness of air quality and the emerging IoT. As was observed in part one of the study, most of the participants in this community were reasonably engaged with the thingness of a device. However, it was also observed that its relation to the very thing it was sensing/measuring was explored relationally to what is measurable, i.e. elements in the air, and in terms of the effect they have on our well-being. In addition, the connection between a device and the *thing* out there foregrounded the frameworks of citizen science relevant here.

Invisible in its nature, air is perceived as something that cannot be affected by one's individual actions. As a major environmental element, air is seen as universal, shared and paramount. Despite the evidence and growing concerns over the effects of air quality, one could argue (even if incorrectly) that we are living in a much cleaner environment when compared to the not so distant past. In recent years, however, there has been a growing interest in and concern about air quality that, as I will argue, has been renewed by recent developments in technology, citizen science, and a growing number of projects similar to the Air Quality Egg (AQE) that will be discussed here.

In his seminal work *Citizen Science*, Irwin (1995) made explicit the link between environmental challenges, global developments and the rise of citizen-science initiatives. Irwin argued that these global challenges and, in particular, the environmental threats "cannot be successfully tackled without full consideration of local as well as global initiatives of citizen-oriented programmes" (Irwin, 1995:6). A decade later, Kera and Graham (2010) introduced the term Collective Sensor Networks (CSN) to describe activities that involve sensor technologies and diverse groups of participants working to integrate sensor data from various environmental sources. Examples of such projects include citizen-led citizen science initiatives that often focus on solving environmental problems affecting people locally. In this respect, as acknowledged by an EU research policy study, "the questions that citizens – not just scientists – seek to answer can set the agenda for environmental research and policy debate" (Science Communication Unit, 2013:3). However, as has been widely discussed, the participatory citizen-led science contributions are often hard to validate, thus leading to conflicting implications for policy, and are rarely integrated (Irwin, 1995, Ottinger, 2015).

Citizen involvement with cleaner air campaigns to influence policies is not a new occurrence. There are numerous examples of citizen-led initiatives that have tackled the local concerns of air pollution. One example is the well-documented struggle of African American residents of the Diamond subdivision in Norco, Louisiana who, through the late 1990s until 2002, "waged a heated campaign against the Shell Chemical plant adjacent to their community" (Ottinger, 2010:245). By the use of analogue tools for air quality measurement such as buckets[139], "activists measured short-term spikes in air pollution levels and compared their data to arguably incommensurate regulatory standards to demonstrate that the air was unsafe" (Ottinger, 2010:245). However, in retelling their story, Ottinger argued that despite

139 Since their invention in the early 1990s, buckets have become widely used by environmental action groups, sometimes referred to as "bucket brigades". The air is collected in the bucket that is lined with a Tedlar bag. Air is collected at regular intervals and samples are sent to labs for analysis. For more details on bucket brigades, see O'Rourke and Macey (2003).

the rhetoric of how citizen-science could influence the research directions and policies, there is a visible disparity between the methods and data created by citizens and those created by scientists. As she pointed out, it is the employment of standard practice for measuring and evaluating air quality that determines to what extent and in what ways non-scientists' knowledge production is assessed. Ottinger argued that "regulatory standards for air quality, combined with standardised practices for monitoring, provided regulators with a ready-made way to dismiss activists' data as irrelevant to air quality assessment" (Ottinger, 2010:246).

The advent of the IoT brought about a new opportunity not only for the development of an easily accessible set of new digital tools, but also of networked capabilities which, together with real-time data storage and analytics, offered the potential of overcoming previously experienced difficulties with analogue tools. This chapter will focus on an analysis of AQE sensor device development, and the subsequent rise of a community-led network of devices measuring air quality. Besides highlighting a number of social and technological issues that are involved in such an enterprise, such as a community approach to measurements and calibration, this chapter will foreground the practical difficulties involved in such an enterprise. While contributing to the spread of know-how is fundamental here, the difficulties this community faced were kindred to those already highlighted by Ottinger (2010), and which are still deeply-rooted in a dichotomy of science versus citizen science discourse. However, it must be noted that some of the latest examples of AQE application in such a context signal a change in this domain. More importantly, this chapter seeks to unveil the processes that were put in place by participants through communal action and how, in such processes, the space for open IoT was created, where the knowledge and the 'thing' and 'device' could be formulated, articulated and disseminated (Vincenti, 1993).

As many have argued, it is an inherently complex process to define the very concept of 'things' that can act upon, measure, or provide services based on real-world entities. It has been noted that enhanced smart devices/objects are still hard to deploy and operate, both on the hardware and software levels, and that the early stage of IoT development has displayed different operating characteristics (see section 2.2.2.). The thing, in the context of the AQE project, will mean two things. First, it will mean the air, the environmental factor of the world, the common, and the actant we want to access. Second, it will refer to an object or a sensor device. Thus, this chapter firstly will attend to a brief history of social awareness and the complexities of air pollutants, and then continue with a study of the processes and specificities are needed to define the shape, form and data of an air quality sensing device, one created by the community of these early IoT adopters. This part of the study will trace the origins, key stages and overall discourse surrounding this project.

5.2. Air Pollution and Social Awareness.

The study of atmospheric pollution is admittedly an untidy science.
(Meetham, 1952:97)

As history has shown, there has been discourse around air pollution for centuries, while the legislative process has been slow and often ineffective. In Britain, the first recorded effort to combat air pollution dates back to the reign of King Edward I in the year 1272, when at the request of some noblemen and clergy, the king banned the use of sea-coal. “Anyone caught burning or selling the stuff was to be tortured or executed” (Urbinato, 1994:1). The ban seemed to have little effect as in the 14th and 15th centuries other measures to regulate the use of sea-coal were introduced by subsequent kings (Kotin and Falk, 1964). In 1661, John Evelyn, a notable diarist of the days of King Charles II, published the anti-coal pamphlet: *Fumifungium: or the Inconvenience of the Aer and Smoake of London Dissipated.* Pleading with the King and Parliament to do something about the burning of coal in London and its effect on the health of the citizens, he wrote: “Aer, that her inhabitants breathe nothing but an impure and thick Mist accompanied with a fuliginous and filthy vapour...” (Evelyn, 1661:2). However, his message had no effect, and the pamphlet was forgotten for more than a century (Staniforth, 2013). In the 19th century, famous fogs were widely referred to as *pea soupers,* or as a *black smog,* and more frequent references to their effects on health and premature death were made (Stern, 1982; Urbinato, 1994).

In Britain, it was only after the Great Smog of 1952 that real reform was passed by Parliament. At the time, it was believed that 4000 people had died from the Great

Smog[140]. Parliament took action, passing the 1956 Clean Air Act (Davis et al., 2002). Today, European air quality is managed by directives issued by the EU, set in place in the 1980s with Directive 80/779/EEC, which set air quality limit values (AQLVs) and guide values for SO_2 and suspended particulates (SP). Later directives set limit values for lead, nitrogen dioxide, and ozone (DNERI et al., 2004). In the United States, it was the investigation into the Donora Smog Disaster that led to the first federal Clean Air Act, passed in 1955. In 1948, the town of Donora in the Monongahela River Valley, Pennsylvania, was covered in toxic smog caused by a weather inversion. It trapped a cocktail of sulphur dioxide, carbon monoxide, nitrogen oxides, fluoride chlorine and metal dust emitted from local coal-burning plants and furnaces located in the valley and town. Over four days, 20 people died, and 7,000 were reported to be sick (Townsend, 1949). The Clean Air Act forced the plants and furnaces to close down. It was in the late 1950s that the first links between air pollution and motor vehicle emissions were made, with the State of California enacting legislation requiring its Department of Public Health to establish air quality standards for vehicle emissions. This led to the federal government's Motor Vehicle Exhaust Study Act of 1960, and subsequent legislation. As with air pollution in the previous century, some of the legislative acts proposed later were seen more as a nuisance, and never got passed or taken seriously (Stern, 1982).

Fifty years into their accelerative growth, the number of petroleum-fuelled motor vehicles on the roads, globally, has become a major source of air pollution (European Environmental Agency, 2015). In early 2016, the World Health Organisation issued a warning about deadly levels of pollution in many of the world’s biggest cities. Pollutants not only exceed the currently set safe air quality values, they also kill millions across the globe (WHO, 2016). As the WHO has shown, air pollution has worsened since 2014 in hundreds of urban areas. The WHO warns there is now a global “public health emergency” that will have untold health and fiscal implications (Vidal and Helm, 2016). Only two weeks into 2016, London had already exceeded its annual limit for nitrogen dioxide (Vaughan, 2016). As a study done by researchers at King’s College London has shown, 9,500 Londoners die each year because of air pollution, twice as many as previously thought. “The premature deaths are mainly due to two key pollutants, fine particulates known as $PM_{2.5}$ and the toxic gas nitrogen

140Later research placed the death toll around 12,000 (Bell and Davis, 2001).

dioxide (NO_2)" (Walton et al., 2015:29).

It is widely accepted that there are various air pollutants that differ in their chemical composition, reaction properties, emissions, persistence in the environment, ability to be transported long distances[141], and eventual impact on human health. Yet, they share some similarities and can be grouped into four categories: 1. Gaseous pollutants (SO_2, NO_x, CO, ozone, volatile organic compounds); 2. persistent organic pollutants (dioxins); 3. heavy metals (lead, mercury); 4. particulate matter (Kampa and Castanas, 2008). Similarly, there is agreement on how each affects human health[142]. Many have wondered why it has taken so long to recognise the deadly effects of air pollutants on human health and why there has been little action to combat this situation. In their attempt to survey the literature on correlations between air pollution and human health data, almost a decade after the Clean Air Acts were installed, Kotin and Falk (1964) pointed out the very problem with the concept of clean air in the Annual Review of Medicine. As they explained:

> *A major consideration in the recognition of potential adverse health effects of air pollution is the knowledge that pure urban air from a chemical viewpoint is virtually non-existent. Movement of air and dilution of pollutants in the large volume of the atmosphere are the two chief mechanisms of air purification. Interference with either, or, as most frequently occurs, with both simultaneously, results in the accumulation of progressively increasing levels of pollutants. (Kotin and Falk, 1964:234)*

Bohm (1981), writing about the correlation between increased lung cancer and air pollution, suggested that this inability to grasp the seriousness of the issue is rather a question of human perception: "Mankind accepts the risk of long-term and low-level exposure to carcinogens. As a rule, immediate benefits are sought and remote

141 In the context of this study, it is important to note the global and transboundary characteristic of the air pollution phenomenon. In the late 1960s, a link was made between the long-distance travel of sulphur dioxides from Europe and the United Kingdom and its effects on Scandinavian rivers, lakes, and forests (Lundgren, 1998, cited in Lidskog and Sundquist, 2011). In 1972, the first international political meeting on environmental issues, the UN Conference on the Human Environment was held in Stockholm. It was here that the first international declaration on 'common principles to inspire and guide the peoples of the world in the preservation and enhancement of the human environment' was issued, highlighting the transboundary nature of environmental issues (UN, 1972). An international UN convention, The Convention on Long-range Transboundary Air Pollution (CLRTAP), was adopted in 1979, with its aim to reduce emissions of airborne cross-boundary pollutants within the UN.

142 For more study references see: Kotin and Falk (1964), Waldbott (1978), Whittemore (1981), Schwartz et al. (1993), Utell et al. (1994), Nyberg et al. (2000), Schell and Denham (2003), Clark et al. (2010) and Smith et al. (2014).

hazards ignored" (Bohm, 1981:371). Seaton et al. (1995), reassessing the limited impact of studies correlating the effects of air quality and human health, pointed out that there might be a problem with the scientific method of capturing this complex issue[143]. In response, by explaining how harmful particles behave in the environment and in the respiratory system, Seaton et al. (1995) proposed the hypothesis that the "acidic ultra-fine characteristics of air pollution particles provoke alveolar inflammation, which causes both acute changes in blood coagulability and the release of mediators able to provoke attacks of acute respiratory illness in individuals."[144] (Seaton et al., 1995:178). They established the current leading theory on the mechanisms through which the particles harm human health, i.e. they cause an inflammatory response that weakens the immune system.

In the last few decades, there have been a growing number of projects adopting a diverse variety of air quality measurement tools to support one or other social or local actions. For example, numerous studies have been conducted on the development of moving sensor devices measuring the pollution of motor vehicles such as diesel buses. In California, the Dump Dirty Diesel Campaign commissioned *The School Bus Monitoring Study* to highlight the health hazards posed to school children by daily exposure to diesel pollutants (Solomon et al., 2001). While this study focused specifically on bus emissions, others use buses for broader citywide air pollution monitoring. The Swiss Scientific Initiative's project OpenSense has installed sensors on the roofs of city buses and trams to create a public air quality monitoring resource (Aberer et al., 2010). Similar pollution-sensing projects using buses have been trialled in the city of Sharjah in the UAE (Zualkernan and Aloul, 2010).

Around the same time as the AQE development took place there were other more citizen-oriented projects. In 2011, in New York, Google funded the non-profit environmental health justice organisation HabitatMap to develop an AirCasting application for mobile platforms. As part of this project, the AirCasting Air Monitor

143"These findings have encountered some scepticism, partly because the concentrations of particles at which effects seem to occur are low by comparison with those to which many people are exposed in industrial workplaces without apparent harm; and partly because no plausible hypothesis has yet been advanced to explain the associations." (Seaton, MacNee, Donaldson and Godden,1995:176)

144Slightly paraphrased for clarity. See Seaton et al. (1995:178).

was developed and later open-sourced as a build-your-own hardware platform (Yap, 2012). In Europe, during the same year as the EU Seventh Framework Programme, a funded consortium of European institutions was established to develop the Everyware project. For part of this larger project, researchers developed an air quality monitoring kit called SensorBox for community-led air quality monitoring (Elen et al., 2012). Today (2017), the discussion in this field embraces many other projects as there are now countless consumer devices for air quality monitoring on the market. The campaigns for clean air have also become more noticeable as this discourse has entered the realm of political campaigning[145]. Nevertheless, as a society, we are still struggling to achieve the desired outcomes in this field. With accumulated knowledge in this field of study and directives issued by air quality monitoring agencies, the impact of air pollution on human life is still perceived as gravely neglected. The rise of citizen science and community-led air quality monitoring networks suggest that the perceived failure of established science to deliver change and the ongoing quest to affect policy-making processes have led to ordinary citizens adopting relevant technologies and organising themselves. Thus, it is important to evaluate past experiences, successes and failures of the early advocates of sensing networks to ensure that these fields of citizen science, technological advance and politics blend together for the benefit of all.

5.3. A Community-Led Air Quality Egg Project

Initiated by the Pachube community of developers, the Air Quality Egg (AQE) project is one of the early examples of the development of an affordable, networked air quality data-gathering consumer device. As noted already, the identity of this community emerged from a loosely associated group of people who were interested in open source hardware hacking, interactive art and media, as well as the use of connected environments, such as Pachube. However, the more organised form of this community emerged through regular IoT community meetups, on both sides of the Atlantic, and can be traced through the digital footprint left on the walls of IoT

145For example see the Clean Air campaign for 2016 Mayoral and London Assembly elections: http://cleanair.london/clean-air-manifesto-2016/; or the campaign run by OneLove Party for 2016 Hackney Mayor election: http://www.oneloveparty.eu/clean-air-immediate-defence-emergency meetups (on meetup.com). Meetup.com is another Web 2.0 platform that has played an important role not only in facilitating offline group meetings in various localities, but also in providing visibility overall for the otherwise dispersed network of like-minded people in different cities. More importantly, the meetup platform has provided this study with evidence that suggests this community's social ranking and their influence on a broader IoT discourse go beyond the confines of academic settings. This helps us to locate the AQE project in its historic setting, its relation to IoT discourse, but also helps us to evaluate this community's contribution to its trigger stage.

In 2014, I conducted a study[146] that mapped out the genealogy of IoT meetups[147]. At that time (2014) there were 251 IoT-related meetup groups in 35 countries and 128 cities, with a total of 60,672 members. By comparison, in 2012 there were only 14 groups in 6 countries, 13 cities, with a total of 1017 members. The study identified the 10 oldest groups (see Appendix V), six of which were initiated by Pachube community members[148]. The first one was set up in New York by Pachube community organiser Ed Borden[149] on July 5th, 2011[150]. In the fall of 2011, IoT meetups were set up in Amsterdam, London, Barcelona, Zurich, Madrid, Munich and Bilbao. Some of these were registered by Ed; however, all of them soon acquired local organisers. Their network relations can be traced by the unique design of their interfaces (see Appendix VI) that echoed the same colour (yellow) used in the original Pachube interface design. The relationships can also be traced by the study of the site records, event announcements and media uploads. The first two years were well documented in all places, suggesting that not only were there strong ties[151]

146The paper titled "Researching the Internet of Things and its spatiality: Actions and Everyday Practice" was presented at RGS-IBG Annual International Conference 2014, in London. http://conference.rgs.org/AC2014

147It is worth noting, that while meetup.com was set up in 2002, in New York, it reached its global audiences in its current format in 2010. In 2011, at the time of first IoT London meetup, there were only a handful of meetups in London.

148There were only two earlier meetup groups with the IoT in their title. The oldest one was set up in Tucson, Arizona on Nov 20, 2003. However, this group was set up originally as the *Tucson Cory Doctorow meetup* and only later renamed as IoT. The second oldest IoT meetup group was set up on February 21, 2009 in San Francisco, and by 2014 had a total of 2230 members.

149His profile stated: 'Evangelist @Cosm @LogMeIn... 11 years in tech startups. Jersey boy.'

150Around the same time, a London based startup was acquired by LogMeIn. See announcement here: http://www.spimewrangler.com/blog/current-affairs/pachube-acquired-by-logmein/

151In an academic context, the meetup.com platform is often analysed in terms of social capital, as a great tool for rounding up the support of volunteers and activists, as well as the role played by the weak ties in the formation and sustainability of communities (Weinberg, 2006; Sessions, 2010). It has been argued that if, in the past, it was strong ties that were seen at the centre of community between the local members but that there were existing communities, now organised within the meetup framework. The findings of this study also showed the spread of IoT interest groups and their enormous popularity as numbers of participants doubled, and in some places even tripled, over two years[152]. Furthermore, the study also indicated that a significant number of global IoT meetups drew their inspiration from the first six. This can be observed by the sites which, for whatever reason[153], adopted the colour scheme used by these Pachube-related groups.

The meetup, both in terms of its online space and offline gatherings, provided a space in which the community could communicate and share experiences, and a space in which their history could be traced. For example, the first publicly-recorded mention of the AQE concept can be found on a NY IoT meetup[154] message board in October 2011, where Ed Borden, a Pachube community organiser, marking the success of very first New York IoT meetup, wrote:

> *E1: A quick note on the Nanode contest: We ran completely out of time and even missed one speaker. I am figuring out how to handle this, and we'll hear more at the next meetup. If you have an idea for a sensor deployment in the city (Joe Saavedra and I were discussing an air quality sensor deployment), contact me! We have Nanodes!*[155]

As noted in the previous chapter, the affordability and simplicity of open hardware and open software led to the popularity of a makers culture and the spread of technological know-how[156], and this was perceived as an important component in marking this community's delimitation. The Nanode[157], unlike the Arduino (2004),

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formation, it is weak ties that characterise the relationships in what Weinberg (2006) calls an electronic-to-face (e2f) community and other professional and social networks. However, Haythornthwaite et al. have found that communities with stronger ties use more media to communicate than those with weaker ties (Haythornthwaite, 2005).

152For example, in London, the IoT meetup members number went up from 959 in Nov 2012 to 3304 in August 2014. Today (2017) this group alone has 10650 members.

153I could not observe any other relationship, neither through the group's organiser relations nor the particular content of these meetups. In some cases, however, the organiser had a link of their interest highlighting one of the original six meetups.

154The NY meetup site was, as noted already, first registered as Sensmaker meetup. However, around the same time the London IoT meetup was set up, NY site changed the Sensmaker identity to that of NY IoT meetup. Later it was turned back to Sensmaker, and finally was taken offline in 2015.

155See original announcement here: http://www.meetup.com/sensemakers/messages/boards/thread/16727242

156See Kuznetsov (2010) and Kera and Graham (2010) on impact of open hardware.

157See more information on Nanode project here: http://www.nanode.eu the most popular open source microcontroller board available on the market at that time, had onboard internet connectivity. This small difference made Nanode that much cheaper and an ideal platform for IoT experiments. If until 2011 the focus was on access and control of an object, with the development of Nanode, focus shifted to the networks of controllable objects. It is worth noting that Nanode was developed by Ken Boak[158] and London Hackspace[159], and in its early stages was supported by the newly incorporated Pachube enterprise[160] through bulk orders and distribution, as signalled by the announcement above.

During 2011-2012, there was significant interest in the development of sensor devices in the context of citizen science. As previously mentioned, as well as the AirCasting Monitor in New York and SensorBox of Everyware project in EU, there were projects like CitiSense - a pilot study by a group from the University of California, San Diego and LaboCitoyen, a project based in Paris, France, similarly proposing the development of low-cost devices for citizen engagement. From the start of the project, this group of developers wanted to do things differently. Nevertheless, from early on, the AQE community tried to distance themselves from other such projects. This was mainly due to two factors. Other projects were seen as strategies to utilise citizen science using a more top-down approach, and as a development of proprietary ecosystems. Opting for the development of a broadly available open IoT product rather than a specific or experimental community solution approach, or the release of a how to guide, was seen as the only feasible way to reach a mass user base. The following examples, 2,3,4, illustrate the core difference this community chose to highlight. There are three main themes that stood out and could be observed, often repeated in meetings and conversations by various actors. These particular examples are taken from the key developers of the project and thus best elaborate the underlying themes. As can be seen in Example 2, taken from a presentation delivered by the already mentioned Joe Saavedra, crucial to this development was the idea of multiple developers and voices participating in decision-making, which was seen as a pedigree for the democratic nature of the project.

158See Ken Boak explaining Nanode here: https://www.youtube.com/watch?v=lLI3hNbxRSM#t=41
159See London Hackerspace Nanode site here: https://wiki.hackerspaces.org/Nanode
160The first patches of Nanode's were assembled by the London Hackspace community during Nanode workshops or were available in unassembled form.

E2: The most valuable part of it is the way it is extremely democratic and a community-driven project. Even from the concepts, to every part of development now: the hardware, the software, the productization of it. All those things are happening simultaneously from multiple communities.

Example 2 talks primarily about the community of developers and the difference the structure of a dispersed, globally-distributed multitude of participants makes in comparison to other projects in this field. As can be observed, the speaker is emphasising the democratic nature and community-driven aspects. Such framing implies that 'other projects' might not be democratic, and do not include the voice of a community. For example, in the case of the Everyware project, the developers of the air monitoring kit applied a scientific approach. As it was established scientists and academics in the field of air monitoring who developed this kit, there were only a limited number of units built and used in trials by selected community members. In contrast, the AQE community members were seen as self-selected, thus reflecting the community’s alignment with the ideas of self-organisation. Likewise, emphasising democratic mechanisms, the speaker also hints at the political aspirations of this project, discussed previously. It is worth noting that the speaker was challenged after this statement by a member of the audience and asked to explain what he understood by 'democratic'. His answer, interestingly, pointed to what was perceived to be public spaces, such as Meetup.com, where events were advertised, discussed and documented, Github.com where all the codes are published and documented, and public workshops open to the public for anyone to join in.

Example 3, taken from the email posted by Usman Haque on the community's mailing list, in turn emphasises the difference of the 'thing' itself and how a community approach can and should capitalise on its members' closeness to the 'thing', both in terms of the device and the entity. The speaker turns to the value of users/participants within this community and what they can bring to the interactivity and the way the system operates and its supporting applications. This was posted during the conceptual development stage of the AQE project and, as such, well illustrates the aspirations of the project rather than the final outcomes.

*E3: we're not (i think) simply trying to build yet-another-air-quality sensing system that passively monitors the environment; or simply trying to replace an official network with a distributed/citizen-led initiative. we are (i think) trying to do something authentically participative that goes to the heart of why exactly people (i.e. citizens/normal people/everybody) would even want to *know about* and *do something about* air quality. by way of analogy, there's a difference between a security camera that continually streams footage in the hope of catching something significant; and a hand-held still camera that encourages -- actually *requires* -- the bearer of the camera to think about the moment of taking a photo and then trying to recognise and capture something significant. there is a completely different participation with and interaction with the generated 'data'.*

As with the previous example, the start of the sentence frames the position by separating this project from 'other' systems that he characterises here with the attributive clause, thus implying that other devices/projects are 'passive' and that 'this project' aspires to develop an 'active entity'. Likewise, the “requirement to think about” by providing a human feedback option to the otherwise passive observation system is seen as key to developing an innovative and unique system. It resonated across many discussions and often provided a fertile ground for “thinking” further and conversing about such system applications and, in particular, the tagging mechanisms that could be employed. The third key argument about the uniqueness of such a community-driven approach to air quality measuring was that of network density. Example 4, already discussed in the previous chapter (see page 134), best illustrates this argument about how the density of distribution of air quality measurement devices that such a network of everyday people could provide is what sets this project apart from government-run networks, or any other top-down infrastructures.

E4: even if our data is not validated scientifically or in that technical direction, I hope that we get the right information to say – there needs to be more study. The air quality sensors like this are really – it can be the go to for application real high-end sensors. I mean, the government has picked the places to put sensors, but what if we say, well, there are real pockets here that you need to be careful about. Or ' right around the school there is a traffic intersection that we have really, really weird readings and we changed our sensor three times and we’re still getting real weird readings, you know, further investigation! And that’s a win right there. You know, whether or not data is great or not I don't really care.

Example 5 hints again at power relations and makes a suggestion as to how such tools in the hands of many can generate knowledge about local issues that often are overlooked by a more centralised viewpoint. Likewise, this example offers insight into the key and, at the same time, most contested value the project has created – that of data created by the device, the system and the community at large. The data will be discussed later; however, it is important to note that it is this belief in data acquisition that is seen as empowering the actors' agency.

The themes carried in these examples established the base for the community-led AQE project from which all other aspects, such as prototyping, production, dissemination and decision-making along the way, would draw reference. The term 'community approach' echoes across time. Be it a conversation about the process, methods or data, participants often used the term to challenge each other's arguments and thought processes. In the following sections, the study explores the means and tools used to support this 'community approach' throughout the process of prototyping and production, as well as how and if the decision-making was affected by both the spatial configuration appropriated in these processes, and the community's insistence to do it in public view.

5.3.1. Prototyping in Public

Everyday life is the realm of 'messy', the impure, a 'conjunction of habit, desire and accident' (Kaplan and Ross 1987:3, in Gardiner 2000:16)

To ensure the democratic and public framework highlighted above, the project continued to utilise the IoT meetup network through a series of AQE-specific meetups. After the initial NY IoT Meetup, just six days later, on October 16th, the next meetup was held in Amsterdam entitled: "Amsterdam is here for you to Build". The workshop host was Usman Haque, who introduced the Pachube concept to the local makers' community and, as in NY, during the workshop free hardware was distributed. On November 18th, the next Amsterdam meetup was titled "Breathe, Amsterdam", and a month later was followed by the "Air Quality Egg Hack-Day", on December 17, 2011, during which the first AQE prototype was built.

It is worth noting that besides appropriating the use of existing online spaces, such as the Meetup platform or communities' wiki sites and Google groups, for managing and disseminating their production processes, the AQE community engaged with a number of physical spaces, most saliently those dedicated to supporting media art and the creative use of technology. In Amsterdam, workshops were held at the WAAG building, home of Amsterdam's Art, Science and Technology Institute. On December 2nd, another workshop took place in New York. This time, it was hosted at the NY Art & Technology Centre Eyebeam. The workshop was led by the aforementioned artist Mark Shepard who, in his artistic practice, investigated the social, cultural and political implications of pervasive media and ubiquitous computing. During January 2012, another meetup was held in New York entitled the "AQE Jam session"[161]. There was one more meetup in New York[162] to finalise the Kickstarter campaign after which the teams from both Amsterdam and New York met in London to participate in the aforementioned Citizen Science Summit 2012 (CCS)[163].

If the previous chapter provided us with some insight into the individual voices of those who gathered at this workshop, here I will provide a more ethnographic account of the context and social life of collective action that took place. The start of the first day was rather hectic as the key organiser, Ed Borden, had missed his train from Amsterdam, and subsequently his opening speech at the conference was cancelled. An hour later, teams from the three cities started to gather in the Summit Challenge area. They slowly assembled around a few tables and began to mark their location that would be their workshop, advocacy and networking central for the next two days. As they gathered, it was unclear if they would stay in this room or would be moved to some other, less central location, allocated to them by the summit organisers. This confusion was short-lived. As soon as Ed arrived he held a briefing on how and what their strategies for the next days would be. In the following transcript of this meeting, there were numerous things that got revealed not only

161 The aim of this meetup was 1) to define the application and user experience, and 2) plan for the Kickstarter video shoot (the following week). http://www.meetup.com/sensemakers/events/48237032/

162 http://www.meetup.com/sensemakers/events/48237682/

163 The challenge the AQE group had prepared for this workshop was to get AQE prototypes set up and running in a real-life environment, and for the first time to try to upload some of their data in real-time to the Pachube platform. http://www.meetup.com/iotlondon/events/48380852/

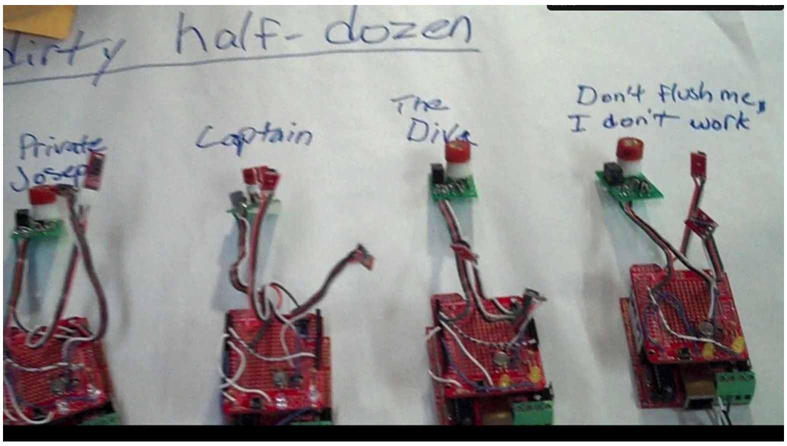
about the approach the team would employ here, but also about the setting and its impact on their work.

E5:
S1(Ed): *"this place is pretty all over a place and there are talks and crap like that....so, our strategy here ...I think it's going to be...like... to get in the <u>center of this thing</u>, like bring all our crap to the table.....we gonna be <u>super organised</u>.....we going to be moving, and people, like, will be gravitating to us.*
S2: *if we look at the questions there (speaker points to the AQE poster they have attached to discussion board), there are <u>three categories.</u> There is a technical category, there is user interface, and then there is more branding stuff.*
S3: *Yea, so it's really ...<u>hardware, software and branding</u> (speaker uses a hand gesture to assign each category to a specific person). Is that's what you mean by user interface? Or are you talking about <u>interaction</u>? Interaction, ok*
S1*: yea, pretty good, yea!?*
S4: *I thought <u>you were doing hardware</u> …*
S3: *no, no, no... (hesitates) I build six units that has No2, Co2, temperature and humidity...and I have code working perfectly and it's got a button, if we going to do the button thing...*
S4: *o cool...<u>you did what I did....</u>*
S3: *exactly ….*
S2: *So, what we need to do is to talk to the WiFi people here as they have ...*
S3: *no, I think <u>we can share the DHSP out of our laptop</u>. So, your laptop connects to their WiFi?*
S2: *yea, but it <u>signs off every 15 minutes</u>*
S3: *damn it …. so that's what we should resolve right now, as <u>this is a big problem</u>...*
S1: *this is another thing. I just talked to organisers, and it sounds like this is going to be kind of crappy day, it's going to be very destructing, and what's going to happen is that tomorrow, we will get a chance to pitch the group or something about challenges. So, what I want.... what I think we should do, is we can spend time today like <u>really getting super</u> … like <u>prepared</u>, <u>organised</u>, maybe <u>get something done</u>, so that tomorrow we can be like.... Hey! Jump on this!...you know, the train is pulling out!*
S3: *we should install one of them. What <u>they don't have – it is closure.</u> There is no closure...I mean, it's the Nanode, shield....*
S2: *so what kind of people do we have here?*
S3: *today, I don't think we have many makers.*
S4: *what kind of tools do we have?*

(Two conversations get spoken over each other: one about the potential audience, and other about the lack of tools provided by the organisers and the tools the team has brought with them)

> ***S1:*** *So, this is what I want to impress. Even if nobody comes to our train, which they will.. but even if nobody comes, at least our team should get things done. By the end of tomorrow, we have a freaking package ...and the best case, tomorrow at the reception if there are no other good presentation then ours, that's ok ….we will be nice and long and we talk it up and we go on drinking and everybody will love it …*
> ***S5:*** *So, what do you need practically?*
> ***S1:*** *So let's get the hardware out so we can dump it on a table and that will bring people over.*
> ***S4:*** *can we claim a table now?*
> ***S2:*** *we already have a table ….*

With this brief encounter, the team got organised. The boxes were unpacked, piles of sensors, cables, post-it notes, coloured pencils, soldering irons, computer chips and laptops were set up on the table, while the information boards on the side became the main strategy and mood boards around which conversations could be initiated. The central part of the table was dedicated to the six AQE prototypes that had been produced by the team from New York, notably Joe Saavedra.



6. AQE prototypes at CCS, 2012. Image by Dorien Zandbergen.

As can be observed in this picture, the participants then called these boards 'the dirty half-dozen', and chose a name for each of them. The names signified their strength or weakness as each of these boards, while programmed with the same firmware and having the same hardware, exhibited different behaviours when switched on. This not only signals how rough and ready this development approach was, but also how unstable were the technologies such projects had appropriated.

The ideology of these meetings encouraged democratic conceptions of self-organisation and participation. What my observations reveal is that there were a clear strategies and number of tactical approaches employed to support such framework. Without a doubt, there were certain expectations on how the events should unfold, and what should have been achieved by the end of it. What from the outside might look rather chaotic and disorganised actually was comprised of well thought-out strategies and improvised tactics in a competitive environment. For example, as noted already, arrangements made between the participants at the start of the day set the framework for the events, while the roles assigned to each participant offered positions they could embrace as they went about promoting the collective goals.

Similarly, there were ad-hock tacktics employed when conflicts arose within the group, or when collective identity was negated in a context of the other. For example, in the above transcript, the internal dynamic between participants can be observed when the three main strands of hardware, software and branding were called out. While assigning each category to a particular person, speaker S3 gesticulated and by waving his hand allocated each strand to a specific participant. This created confusion as S4 interrupted S3 with the utterance “I thought you were doing hardware.” His initial response of “no, no...” followed by hesitation and subsequent confirmation revealed the initially invisible tension between the two developers. As I later learned, it was at this London meeting that the team from Amsterdam discovered that the prototype made during the Amsterdam workshop had gone missing and the six new prototypes present had been developed by the developers in New York. Initially, this seemed to create some tension between the members of the two teams. However, as more London-based participants joined in the workshop, working to achieve the set goals was underway and the team continued working together without any animosity.

The other tactic involves the notion of the common world, from the literal application of Arendt's table that as a common world “gathers us together and yet prevents our falling over each other” (Arendt, 1998:52–53*)* (see section 2.2.3) to objects that created the focal point for engagements. Thus the team's table created a space that could be shared by the community and the newcomers. As illustrated already in the meeting transcript, the members of the group were clear about its value and the important role it would play in their collective action. They 'claimed their table' at a very visible spot, they 'dump(ed) hardware on a table', and they rallied people around it. During the two-day event, the table was extremely popular and many people joined in to discuss the project, learn about the devices, and brainstorm applications. Likewise, the provision of some already configured pieces of software or hardware offered a clear focus for action, but also a framework that those from outside could rally around. For example, as the initial conversation revealed, the context of the Citizen Cyber Summit, while providing a general context for their work, also brought about uncertainties about possible participants and the location at the UCL campus. Furthermore, its network infrastructure determined possible limitations marked by 'it [the network connectivity] signs off every 15 minutes'. Such a setback offered an opportunity to those interested in networking, both inside the community and those participants from outside, to share, negate and find a solution to the problem.

In the initial briefing, the question also arose about the lack of packaging for the units. This quest to find a solution for possible packaging became a popular engagement opportunity for those with fewer technical skills or those who otherwise could not contribute to other aspects of the tasks at hand. While the solution was found at the nearby Burger King counter in the form of their perfectly sized ice cream cup with its lid, the collective walkabout was also an opportunity for participants to get to know each other and share their convictions for engagement or interest. When the participants brought the potential packaging back, another workshop on how to adapt these for the shields and cables was set in motion, and became yet another opportunity for engaging otherwise passive observers - another example of emergent tactic employment.

One of the key challenges the group set for themselves was to get the devices 'out in a wild', connected to the net, and to get them to stream some data. This strategy not only involved people organising themselves into groups to locate possible hosts, but also encouraged people to leave the 'table', and to engage with people outside the walls of the summit. This is a challenge that any developer finds difficult but it is also a critical challenge for citizen science projects as their aim is to engage citizens beyond their immediate circle. I followed one of the groups that initially found it difficult to convince the local shopkeeper to host the setup for a few hours. It was the weekend, and the manager who could make a decision was not present. Finally, after wandering the streets for some time, the group spotted a local computer fair on the second floor of a large building. The group went in and located the nearest electric plug to the window and asked the seller at the nearby table for permission to plug in their device. After a short hesitation, the seller joked 'as long as it does not blow up'. A short conversation followed during which the group explained the meaning of the device and their experiment. The seller was not impressed but did not abstract the instalment of the devise. The second device was set up at the entrance of the University building as no other locations were found in the time available.

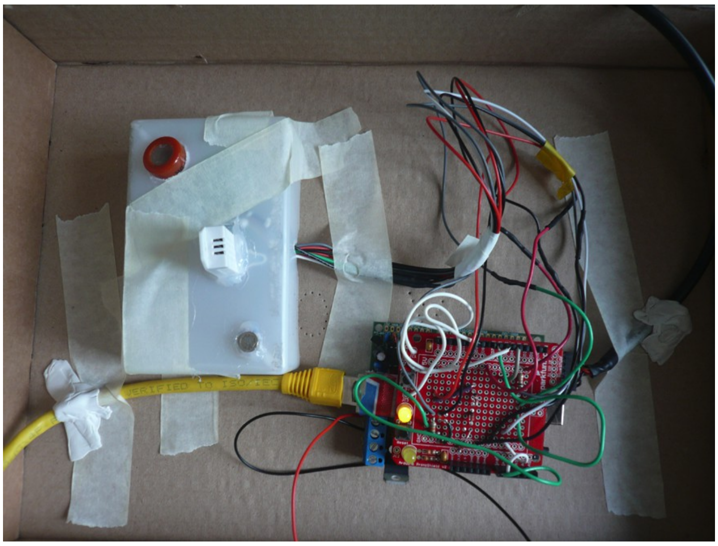
As the final presentation was approaching, the team became aware that their set aims were far from being achieved. There were only two devices connected and the data received was rather random. Another tactic was then put in action. The team agreed to behave in a positive manner and focus on the project's wider framework. In their final presentation, they admitted that the data received was 'rather unreliable'. The lead developer rationalised this with the fact that devices had been severely 'hacked' during the workshop, and that some 'messy code (had been) added' for mobile connectors, etc. In the end, the team demonstrated exuberance, and the presentation was given in a cheerful and celebratory manner. The projection showed the abstract data charts on the Pachube data platform, and the key achievement presented was the fact that the sensors were sending some data, with updates being sent every 15 seconds. The key organiser also highlighted the fact that “it was the first time we have these units together. We have no idea how to interpret this data yet. We don't know what this means. But now we are a step closer”. The presentation, having been given in an enthusiastic, cheerful and celebratory manner, was well received.

By highlighting the process-based nature of the project rather than the immediate goals, the organiser here evoked what Robert Axelrod (1984) called "the shadow of the future”. The shadow of the future, as Axelrod argued, is the promise of continued interaction – the key to successful cooperation. Evidently, such rhetoric not only communicated to outlookers what was important to celebrate, but also served as a reminder to his own peers that there was further work to be done. It is also interesting to note that while the speaker drew attention to the fact that it was the first time that the units had been brought together, it was actually the first time the members of the community had come together too; as all the units had been developed by the same developer in New York, it was thought that the team had been 'together' from the start. The second reading of this misrepresentation could be that it was the first time for the 'units' to be plugged into a network and for them to send data simultaneously, even though it was only two 'units' that had been plugged in in a real setting and had transmitted data. However, assessing these two possibilities, I would argue that it was the first which was at play. The rhetoric of 'coming together' was much celebrated over the two days, and most of these occasions were situated in a context of community; having had an opportunity to meet each other was acknowledged as the most exciting part , be it when discussing code or sensor particulars around a workshop table or engaging in discussion in a pub afterwards. This leads me to conclude that the speaker's intention was most likely to highlight both processes – the coming together of this community and the act of units being plugged into a real-world situation.

A month later, I met the team again at the next public workshop, this time hosted by the Center for Creative Collaboration (CCC) in London. The two-day workshop was set up for a much smaller group of participants, while the organisational style much resembled the one experienced at CCS. As at the CCS, there were clear strategies for engagement and tasks set for each day of the two-day workshop. The first day was set up as an Intro to Data-Making for 'the beginner Arduino/Pachube user', the participants learning how to create data feeds, input data using simple manual tools (websites and mobile apps), and then automating the process via an Internet-connected Arduino'[164]. As described in this meetup post, the main focus of the workshop was on how to use the Pachube data platform and upload the data from the Arduino board. It was attended by about 20 people, and many I spoke with found it very useful, informative and rewarding as it provided learning through a hands-on practical approach.

164 http://www.meetup.com/iotlondon/events/55961232/

The second day of the workshop introduced the use of the Nanode platform, focused on the AQE prototype unit assemblage, as well as achieving connectivity with the Pachube platform. All the participants were able to build their own AQE devices by assembling and soldering sensors, connectors, resistors, capacitors and LEDs onto a Nanode microcontroller board. The assembled units, equipped with the latest firmware, were then connected to the Internet. As data was uploaded to the Pachube platform, it became observable in a browser window. Attended by a group of 10 people, all from different backgrounds and with varied skill sets, the workshop was an opportunity not only to assemble the AQE unit from the ground up, under the supervision of the workshop leader who was the main developer, but also to seek advice or help from fellow participants if difficulties arose. Participants had everything they needed to complete their tasks. The hardware parts and sensors were pre-ordered and packaged into separate unit packs. Soldering irons and other instruments were supplied for all to share. To focus everyone's attention on action, a clear step-by-step guide for assemblage and ‘how to install’ documents were projected onto the main screen. There was also lunch provided, and sufficient space for interactions.



7. AQE unit assembled during the CCC workshop. March 29th 2012. Image by Ilze Strazdina.

While the participants never really managed to install the units 'in the wild' as the workshop organisers had suggested in the promotion material, participants self-organised moves to relocate the discussion part of the workshop to the nearby park, created an opportunity for more spontaneous interactions. The discussion did not touch upon the topics suggested by the organisers, such as what possible applications of the AQE could there be or whether the installation of a human trigger-button would help interactions. Rather it was opened by one participant with the simple question: “What are we building? A product or a new society?” As participants responded to this provocative question. their diverse stands and motivations to take part were unveiled.

Reflecting on the practical part of the workshop, one of the participants acknowledged the technical hurdle: “Definitely not a new society, at this point or level of involvement and knowledge required to build one of these....”. Another brought up the fact that the Clean Air network in London had quite a good coverage of air quality sensors across London, and also adequate maps illustrating the data. Another person finished his thought by suggesting that the AQE could be used to 'verify the data and see if it is correct'. Acknowledging the lack of accuracy of the AQE data, someone else suggested it would be interesting to see the change over time: “It’s that sort of thing – weather effects, traffic effects, school half-terms. We could see how everyone's environment is affected by such.”

Soon after, the discussion turned to the question of the participants’ motivations. “Why did you want to take part in this workshop?” Reflecting other responses on motivation collected during this study, there was a variety of motives presented. While the majority had some technical interest in the hands-on experience of building the unit itself, the wider interest frames varied between more technological concerns about currently available data-gathering tools and their accessibility, to social aspirations such as involvement in everyday communal learning or more activist-orientated questions of empowerment and the political implications of citizen sensor network data. One possibility of a project such as the AQE was the opportunity to develop DIY tools. For some, interested more in home automation and tinkering, this was a great chance to, as one participant put it, “hack on hack”. Either to extend one's learning about the outdoor environment through the use of such tools or by the application of more artistic methodologies, as a tool for disrupting the IoT discourse of dominant space by distributed citizen engagement, it was seen as a positive tool for change. For others it was the promise of a tool for 'verification of data' or, in other words, as a tool to question the accuracy of 'official' data. In the previous chapter, I highlighted the correlation between the concept of 'official' with that of 'government' data. At this workshop one participant, who identified himself with the utterance “I work for a corporation”, signalled the relationship between 'official' and 'commercial'. He asserted that “you certainly can't trust commercial data”, rationalising this statement by the fact that data of vendors 'claiming a certain performance' could not be trusted. Likewise, he argued, the increased privatisation of these agencies increased the possibility of data being misrepresented.

The wider context of IoT development was also raised. “Somebody has to build it” exclaimed one of the participants. The others argued that at this early stage of IoT development, it was the role of such independent projects to highlight the 'conflict between interests', and assert the social and activist interests in this development. While the question of data accuracy, needed to provide the political statements rooted in a comparative study, was raised, it was the appropriation of concepts such as the ‘city as platform', which could be used to create more open standards to provide a standardised way for a multiplicity of sensing projects, that seemed a more constructive way forward.

There were also more perceptive questions put forth. “What does measuring things do?” asked one participant. By quoting the Victorian polymath Francis Galton, “the only way something exists is if you measure it”, a participant opened up a discussion on engagement through a medium: How does the use of IoT device change one's perception and conception of the world? As in other events observed, there were more questions raised than attempts to answer them. This not only reflects the nature of these gatherings, but also the time, i.e. the early stage of IoT development, and the exploratory, community-based contexts they were set in. Driven by the common task to enhance the collective process, both in terms of the AQE device development and the expanded hands-on knowledge of individual community members, these workshops encompass the idea of a learning economy where tacit learning is perceived as key to a project's success.

Thus, I would argue, the method which was adopted for the prototyping stage revealed the community's initial desire to master this next stage of IoT development in an open and public manner. The appropriation of platforms such as Meetup, an online, privately-owned space, and public physical spaces, such as museums and media centres, reveals the hybrid nature of spatial configurations the community navigated to achieve the desired public discussion and engagement through hands-on learning in peer-to-peer frameworks. However, my observations revealed that the most productive discussions and sparks of creativity took place in physical environments when the community came together. These physical, real-time workshops provided the space where ideas, concepts and approaches could be negotiated in a creative and often chaotic manner. While there were clear and observable strategies adopted to encourage engagement, the framework was sufficiently open-ended for people to feel motivated enough to seek collaborative solutions. In contrast, the online spaces mostly provided the tools for organising and managing the meetings, event announcements and follow-ups. However, the question remains: how much did these local, public discussions influence the technological development itself? In the next section, I will explore the next stage of AQE development in which the production and distribution of the AQE device were realised and how, in this process, the network of actors was extended beyond the initially identified CoP formation.

5.3.1. Hacking the Growth: the AQE Kickstarter Campaign

After a number of prototyping workshops, public discussions and the launch of the AQE Kickstarter campaign on March 27, 2012, the AQE project moved to its next stage of product and network production. The campaign was perceived as a pivotal point in the overall AQE development process as it was not only an opportunity to raise the necessary funding for product development, but also as a tool to broaden the community and its participation in the AQE network[165]. The following analyses of the campaign unveil these parallel occurrences and, in the process, highlight the successes and difficulties encountered by its organisers.

165As diverse projects move towards crowd-based ways of financing, platforms such as Kickstarter are no longer seen as an alternative way to finance a multitude of projects (Wheat et al., 2013; Agrawal et al., 2014), but rather as a platform that helps towards an innovative production process (Baldwin et al., 2006), or as a solution to problem-solving (Brabham, 2008). The latter is often explained by way of the theory of crowd wisdom or distributed intelligence that can be drawn from many experts and non-experts constituting the crowd (Surowiecki, 2004).

Launched in 2009 as a platform for artists searching patronage and financial support to validate their artistic ventures, the Kickstarter crowdfunding platform quickly became seen as one of the most disruptive Web 2.0 innovations of its time. Like many Web 2.0 platforms, the Kickstarter was built on the libertarian principles of P2P technologies, enabling the autonomy and participation of many players[166]. The Kickstarter crowdfunding model combines the concept of crowdsourcing, with its focus on gaining contributions, feedback and solutions from the 'crowd'[167] (Poetz and Schreier, 2012), and micro-finance (Robinson, 2001)[168].

Those who have studied the success rates and factors of crowdfunded projects have argued that the success of one or other project is often linked with project quality, which can be identified by signs of preparedness, elements such as an inclusion of video, regular updates, and the lack of spelling errors (Mollick, 2013, 2014). The success rates also depend on the importance of the numbers of friends on online social networks (Etter et al., 2013). Others have suggested that there is a strong geographic component as, most often, investors that are geographically near the project's origin invest relatively early and appear less responsive to the decisions of others (Agrawal et al., 2011). The projects characterised as 'public-good' or having some sort of community benefit have a particularly good chance of succeeding with their campaigns[169] (Belleflamme et al., 2010; Qiu, 2013). A study by Gerber et al. (2012) highlighted that "feelings of connectedness to a community with similar interests and ideals" (Gerber et al., 2012:1) were particularly beneficial for attracting like-minded funders.

166Its economic model, however, is characteristic of the current neoliberal era as it maintains the profit-making characteristic at the core of its entity and thus what Kostakis & Bauwens (2013) call the entity of distributed capitalism.

167See Howe (2006), Agerfalk and Fitzgerald (2008), Brabham (2008), Kleemann et al. (2008) on more detail on discussion on value and definition of crowd.

168Such a model is defined as "an open call, mostly through the Internet, for the provision of financial resources either in the form of a donation or in exchange for a future product or some form of reward to support initiatives for specific purposes" (Belleflamme, et al., 2013:8). Belleflamme et al. have built their definition on Kleemann et al. (2008) who argued that in an entrepreneurial context, the definition provides specificity while allowing room for the continued evolution of the concept.

169Belleflamme et al. (2013) showed that "Building a community that supports the entrepreneur is a critical ingredient for crowdfunding to be more profitable than traditional funding". (Belleflamme et al., 2013:32)

The AQE Kickstarter campaign (2012) could be broadly characterised by all the features highlighted. The campaign exhibited many signs of a high-quality project in terms of its preparedness. The video on site was well designed, and its positive, feel-good soundtrack, supported by visual imagery, told the story of a community behind the design and its concerns about air quality. The text, written in a cheerful and positive manner, emphasised three main claims. First was the community angle[170] of the project, and its aspirations to question air quality data on a local level. The second described the device itself, and the third focused on the open nature of the device and the opportunities the open character of the hardware and its data could provide for future development. The text was linked to other sources, such as a community discussion group and wiki site, as well as articles in the press[171] and sites of core developers. There were a total of five updates posted during the 30 days of the campaign[172]. In response, a total of 76 comments from the project backers were received[173].

This reward-based crowdfunding[174] campaign could be characterised as a successful one. A pledge of $39.000 raised the total to $144,592 from 927 backers. Funders were offered a number of rewards. Initially, there were nine reward categories covering pledges from $1-$25000. Rewards varied from the beta tester of projects open data, T-shirts and stickers to custom air quality sensor shields, DIY kits, or already assembled AQE kits. Likewise, there were distinct categories for the US and non-US supporters. For example, for $100 backers could receive the 'Air Quality Egg. Fully assembled, Plug and Play + US shipping costs', while for $113 backers would receive the same kit + non-US shipping costs. Two days into the campaign,

170The slogan for the AQE campaign on Kickstarter platform reasserted this importance: “A community-led air quality sensing network that gives people a way to participate in the conversation about air quality.”

171At the time there were the number of publications that celebrated the project, from the texts published in The Wired to Forbes magazine. See example McCue (2012).

172Those included the already mentioned introduction of a new reward (March 31, 2012); the upload of a new video illustrating the motivations of the community behind the project (April 4, 2012); an Egg design update, from the key enclosure designer (April 8, 2012); an update on new sensors: Radiation, Dust/Particulates, O3, VOC's, that led to the introduction of a new reward category (April 12, 2012); and a final update titled: Why sensor calibration and precision is the wrong conversation (Apr 15, 2012).

173The largest number of comments (46) were in response to the update about 'on-top' sensor availability. The second largest number of comments (total of 23) were posted after the final update on matters of calibration.

174Mollick (2014) identified four types of crowdfunding models: the patronage model, lending model, reward-based crowdfunding and investor model.

the first update was published introducing the new reward titled 'Sensor up a CITY!" for a contribution of $10000[175]. At the request of the backers, the campaign organiser revealed (May 2, 2012) that the four backers pledging the $10000 were from Boston, Budapest, London, and Moscow. The most popular reward was a fully assembled AQE kit, distributed to 329 backers within the USA and 147 backers from outside the USA. There was another reward category of $250 added on at the request of supporters who were interested in adding extra sensors for other particles on top of CO and NO_2. (See full list of pledges and rewards in Appendix VII)

While the campaign turned out to be successful, problems emerged with the delivery of the project[176]. A Mollick (2014) study based on a sample of 471 projects in the tech and design categories found that over 75% of successful projects on Kickstarter deliver their products later than expected. His study indicated that size and the increased expectations around highly popular projects are related to delays that were attributed to a range of problems associated with unexpected success; manufacturing, the complexity of shipping, changes in scale, changes in scope, and unanticipated certification issues were all listed as primary causes of delays.[177] An update, six months after the campaign[178], confirmed some of the issues highlighted by this study. In a detailed account of the AQE project's past, present and future, the key developer Saavedra narrated issues that had led to the unexpected delays in delivery[179]. He mentioned the fact about 'Kickstarter ending far more successfully than we had

175The reward was described as one that could appeal to a larger organisation or corporate sponsors. In the aforementioned characteristically upbeat language of the AQE ongoing campaign, the message read: "Let's do a big rally to kick it off. We'll come with 100 Air Quality Eggs, run a clinic, do some talks, have an exchange of ideas. Our travel is to include US/Europe. 100 people can take home Eggs: instant critical mass. This is a great way for corporations who want to sponsor this project to get involved to give back to the community or engage their own employees in the movement."

176The proposed delivery date for the first hardware elements was set for July 2012. On June 12th, 2012, the new update on the project's Kickstarter wall gave a glimpse into the ongoing design process. Then there was deep silence until August 1st when the next update emerged thanking the community for their enduring support and updating them with the story behind the scenes or what still seemed to be the early stages of prototyping. On August 23rd, campaigners informed backers about the growing complexity of the project, but announced that they "expect to be shipping Eggs at the beginning of October". In reality, the first AQE kits were shipped as late as January 2013, with the last announcement on shipping issues posted on April 19th, 2013, indicating that the last eggs were shipped out a year after the successful end of the Kickstarter campaign.

177On a positive side, they found that very few projects appeared to give up on delivering their promised products. See interviews by CNNMoney with the top 50 most-funded Kickstarter projects in 2012 (Cowley et al., 2012; Mollick, 2014).

178On November 8th, 2012.

179See the original post here: https://www.kickstarter.com/projects/edborden/air-quality-egg/posts/344943 anticipated' and the fact that due to his other commitments he could not be further involved with the development process, thus handing over the production to a team at WickedDevice[180] who "took on the challenge of developing and now the manufacturing of this unique, and frankly complex system".

Saavedra not only praised WickedDevice's support for open systems, but also the fact that all the components were produced and assembled in the USA, indicating the company's alignment with the perceived ethical character of an enterprise that operates in solidarity and agreement with the ethics of open source: local sustainability and collaborative economy-oriented peer production. This reflects what analysts have called post-campaign shock, a characteristic of many overfunded projects that leads to a rethinking of the overall production process and a change that includes the rollover of management strategies to other parties, and searches for industrial production facilities (Baldwin et al., 2006; Cowley et al., 2012). In the case of the AQE project, the takeover of the production process meant more traditional product design strategies were adopted[181], as well as the subsequent trademarking of the Air Quality Egg on 12 August 2012[182].

In his update, Saavedra also mentioned the support of the COSM[183] (aka Pachube) team that launched the user interface at http://airqualityegg.com/, and the continuing success of numerous AQE workshops held in Europe and the USA. Furthermore, his post highlighted the fact that the Air Quality Egg project had been invited to exhibit at the Venice Biennale, an acclaimed platform for contemporary art. While the tone of the post is celebratory, it also signals the significant shift that had taken place during this post-campaign period. While the initial community had continued its approach of hosting workshops through the global network of allies in the fields of art and design, the eggs themselves had moved into the more traditional sphere of mercantile product production. Furthermore, the renaming of Pachube had created disruptions for the platform users as it not only produced significant confusion in

180WickedDevice is a company based in Ithaca, New York. http://shop.wickeddevice.com

181It meant that further production updates were posted on the WickedDevice blog, with the first blog posted on May 5th, 2012.

182The trademark registry can be viewed here: https://trademarks.justia.com/857/15/air-quality-egg-85715680.html

183On May 14th 2012, Pachube was renamed COSM. As a result, the company's take over by LogMeIn was completed and the new back-end system developed. See announcement here: https://iotevent.eu/applications/pachube-is-now-cosm/

terms of technical upgrades, but also signalled the adoption of a more business, rather than community, oriented approach.

The tension between 'community-led development' and 'commercial product' also created hostility between the AQE backers and project organisers that could be observed on the campaign's Update wall[184]. The year after the initial launch of the campaign, on Mar 21, 2013, the key organiser published an update entitled 'The Last Leg'. There, hinting on a debate that had crossed over to other social media platforms (Twitter, Google group and WickedDevice forum), Ed Borden mentioned the feedback the project had received by characterising it as ranging from 'troll-venom to incredible outpourings of uplifting support'. His following statement encompassed the rising divergence in the nature of the project.

> *E6: 'I personally have never had commercial ambitions in this space and so I never saw AirQualityEgg as a product at this stage. But as a "collaborative, community-led" project grows into a group of people large enough to have vastly different viewpoints, expectations, and opinions, things can get messy. For us, that has translated into delays and cost overruns, eating deep into personal time and pocketbooks. It hasn't been a smooth ride.'*[185]

The comments spaces, such as 'Kickstarter walls' provide the space for asynchronous communications, explored in the field of Computer-Mediated Communication (CMC) research. It is generally noted that online spaces lack nonverbal cues and the social functions those cues play in face-to-face communication. Research has shown that the lack of such social context cues affects users' interpersonal relations; there is less warmth and involvement between users, users became de-individuated and normless, become self-focused, resistant to influence, disinhibited, belligerent, and effectively negative (Walther, 2011). Furthermore, asynchronous spaces, such as comment walls, have temporal dimensions that in turn mean slower feedback and subsequently affect users' expectations (Urso and Rains, 2008). While such space helps to sustain the awareness of other participants, managing users' expectations of communication frequency can be a challenging task that may lead to conflicts such as those observed in Example E6. There was a total of 199 comments left on the

184There was a total of 15 updates and a total of 106 comments received from the backers in a time frame of 12 months following the launch of the project (April 2012 - April 2013).

185For full transcript see https://www.kickstarter.com/projects/edborden/air-quality-egg/posts/433285 campaign's comment wall. Many exhibited some kind of discontent (a total of 46). A significant number of comments signalled a positive attitude and ongoing support, both for the overall concept and the project team's good intentions (with a total of 57 positive and 25 of a neutral nature). A sum of 67 comments were of an informative/neutral nature. There were also 182 comments left in response to campaigns update posts.

The key themes for discontent emerged. Most notably, backers felt uninformed about the progress of the developments. Many commented about the 'lack of updates' or, in other words, they lacked feedback from the organiser, most notably during the period of Aug 2012 to April 2013. As the AQE kits were assembled by hand, by members of WickedDevice and participants who joined Egg assemblage hackathons, the organisers took the decision to ship them in batches of 100. Once the shipping started, there was confusion over who had received or not received their eggs. In addition, delivery delays meant that some eggs took as long as 3 weeks to arrive. Some eggs never passed the international borders due to international standards[186]. Complications also arose regarding the promise to include extra sensors. There was a total of 101 backers who expected the delivery of a device that would include several or all six sensors (NO_2, CO, Radiation, Dust/Particulates, O3, VOC's), as well as sensors for temperature and humidity. It appears that some backers did receive their add-on sensors, while some never did. From comments left on the wall and in the WickedDevice forum, it seems the biggest complication was with the inclusion of Gamma and Beta Radiation sensors for an extra 60$. In his last update, the project creator stated that backers who had ordered the radiation sensor add-on would receive it after the delivery of all the basic kits had been completed. However, backer comments show that the radiation sensors were never delivered[187]. Other negative feedback highlighted issues such as parts arriving damaged or eggs not working properly, as well as broader criticisms of the project, its enthusiasm, and its perceived idealism. The following few examples encompass some of these criticisms, and give an insight into perceived failings:

186One comment revealed: "A friend of mine was not able to get his egg out of customs in Germany due to the fact that the power plug does not have a CE sign."

187Even in the AirQualityEgg V.2, now available at WickedDevice shop, there is no egg available with a radiation sensor.

E7: 'Got mine today. Yay? Not really. This is such a nice example of a bunch of bunglers trying to make a better world. The box is just as is, no documentation, only a letter making sure they are not liable. US plugs, whereas we paid extra for shipping to Europe. What effort does it take to provide other than US plugs. They don't take any responsibility for their product. If the device is defective, it is apparently mainly my problem. I will even have to pay for it being fixed. I will install it and see where it goes, but I don't have any confidence at all in the output. Looking at how the founders manage the project, their inability to deliver on time, their desire to not be held responsible for defective units at all, then how valuable are the readings from the device? Trying to make a better world is one thing, but even sustainability requires quality control and quality assurance. O yes you also get a warning the device is known for causing cancer and birth defects, nice! So I buy a product to create a sustainable world, but the plastic contains cancerous products. The letter states that it is made in the USA, but the hardware itself has "made in China" all over the place. Again, with so many lies and false promises from the start, how can I trust the data from the devices?'

E8: 'For those that didn't receive their eggs yet, don't envy the ones that did get their egg. I got mine but it's still just a plastic box with electronics not working. The air quality egg turned out to be just pie in the sky!'

As these examples illustrate, the projects community and collaboration-oriented vision seemed to be overshadowed by the perceived failings of the delivery of the devices and the communication process. Such failings, in turn, undermined the issue of trust: trust in the community behind the campaign, the validity of the device and, moreover, the data produced by the device. This would not only suggest the campaigns possibly negative impact on the community's overall goal, but also a certain failure of attainment of the concept between the community and the network of supporters that crowd-funding platforms such as Kickstarter provides. As can be observed in E7, the expectations of the Kickstarter backers were not met. The recipient expected a ready-made product. In contrast, previously observed motivations of this community, its DIY and collaborative character, clearly stood in conflict to such an outcome.

The last comment was left on September 9, 2015 (three years after the launch of the campaign). It stands out in this long unattended space, and presents the lone-sounding voice of an individual left disappointed by his experience, a solitary scream in an echo chamber. Yet, while insisting on the AQE campaign failing, it also highlighted the continuation of the project. After the fulfilment of the Kickstarter promise, WickedDevice continued the development of Air Quality Eggs, now marketed as AQE V.2. The comment stated:

> *E9: 'project creator did not fulfil what was promised but still at large selling version 2, guess what, not kickstarter.com's problem'.*

It is worth keeping in mind that some of these comments were responded to in the form of an update or in a short message sent by the developers of WickedDevice, or at certain times by the community coordinator Ed Borden. Some, however, never received any feedback. The lack of feedback left backers to communicate among themselves, often escalating each other's hostility when expressing disappointment about receiving or not receiving what was expected. Hardaker (2010), in her analysis of online communications in the context of Computer Mediated Communication (CMC), suggested that online users would often identify “aggressive actions, such as insulting and attacking others”, and negatively-marked characteristics, such as being “hostile”, “snotty”, and “idiotic”, as “trolling behaviours”.

In such a context, the negative messages, as exemplified by E7 and E8, with their aggressive use of name-calling - a 'bunch of bunglers' - and accusations of 'lies', could easily be perceived as trolling behaviour, and would explain the meaning hidden in update E6, posted by the community's organiser. However, it is not clear if he was referencing the messages left on the Comment wall or the perceived abuse in other online spaces. Nevertheless, it can be observed from responses that some participants chose to write longer messages, asserting their opinions strongly as “facts” and using crude language, including personal insults (a trait uniquely associated with male online users: see Herring, 2000). As noted already, they argued that it was primarily the lack of communication and feedback that sparked their negativity towards the project, as can be seen in the examples below.

> *E10: March 21, 2013*
>
> *"spiteful Internet troll-venom". Probably due to how bad your communication was. You seem to think that just because someone disagrees with you they are an internet troll. You're wrong. People*

have had every right to complain about your inability to communicate with people who invested their hard earned money into this project. I was bitterly disappointed in this project and the lack of communication - it stopped me backing other Kickstarter projects, I know I'm not the only one. Andrea is right, stop feeling sorry for yourselves, MTFU and learn from your mistakes.

E11: March 28, 2013

Sorry @sensemakers the only one who is disparaging the project is yourself. Stop being so melodramatic all the time. Nobody is having a crusade against your project. You raised quite some expectations, of which most are not met yet. Initially, I also decided to stop backing up projects because of the failure to deliver by the aqe guys, but that would be unfair to all the other people who "just did a Kickstarter project". My last pledge (just before receiving the plastic box with electronics) was on the StormFly, which is of similar complexity as the AQE. I am going to let the progress of that project be indicative, whether I should keep continuing supporting Kickstarter projects or not.

The two comments here illustrate another common occurrence. Campaign' supporters often make references to a Kickstarter framework, and how their experience of this campaign might affect their involvement in other campaigns on this platform. This can also be observed in a number of positive comments. For example, E12 is a comment posted short after the update by Joe Saavedra, noted above, explaining the initial delays.

E12: Nov 8, 2012
That's what Kickstarter is all about, the whole process and being able to take your time compared to if you had to deal with a bank loan or funding that wanted their money returned to them. You've done a great job keeping us informed the whole time as well as feeling involved. Thanks!

In contrast to Examples 10 and 11, where the reference to Kickstarter is used to shame and discredit this particular campaign, Example 12 points towards the platform's offerings to experimental, community-led projects. Furthermore, the benefits of a crowd-funding approach are highlighted by the opposition framing of the more conventional approach, that of a bank loan. Thus the use of the platform is aligned with the ambitions of the campaign, and the broader principles governing the innovative approaches associated with the framework of collaboration. As noted already, there was a significantly large number of comments that not only expressed a positive attitude towards the project but also, in some cases, expressed the sheer joy of being able to plug the eggs in. Others evoked future visions, while some had already tried and built additional resources for the AQE network. The following three are examples of positive comments, received a year after the launch of the campaign, and illustrate well the feedback from participants who had received their eggs and were able to join the network.

> *E13: April 9, 2013*
> *I received my eggs last month to Barcelona – Egg + Dust Sensor upgrade. No customs charge. Unfortunately, one of the adapters was not working. I got quick support on the WickedDevices forum and they sent me a new one. Followed the instructions on the Egg Setup page as mentioned in the letter found in the box and my eggs are glowing and sending data to Cosm. Glad to be part of the Air Quality Ride, delays and what not, now it's time to build up something useful from this network!*
>
> *E14: April 15, 2013*
> *My eggs are working great, thank you! I wanted the Air Quality Egg page hosted by Cosm to look a little different, so I wrote a Chrome extension that might be useful to other people.*
>
> *E15: April 28, 2013*
> *Hi!! The first Mexican Huevito (Little egg) live in Mexico. It took a while, but worth it!!!*

The asynchronous space offered by the platform's Comment wall provided some insights into how this stage of the project was received and evaluated by a now extended network of community supporters. However, it tells us little about the supporters' alignment with the goals of the community or reasons for their involvement. As noted before, crowd-funding platforms offer opportunity for new social interactions, attracting like-minded founders who share feelings of connectedness to the community and its ideals (Gerber et al., 2012). Messages on a comments wall offer only a snapshot of participant feedback and, as observed in my study, many of these messages are left by the same people. Frequent references made to the Kickstarter platform itself also suggest that some backers might more identify with the Kickstarter supporter community rather than the community of AQE as such. However, it is incontrovertible that over 1000 AQE devices were shipped and plugged into the network; thus, a significant number of people did join the campaign, and subsequently the AQE community network. In the next section, I will examine more closely the social fabric of this network and its geospatial footprint.

5.3.3. Social and Geospatial Alignment of the AQE Community Network

As people started to join the campaign, it was valuable to see what motivated these early adopters of technology and supporters of the AQE project. Data on this subject was collected by the campaign's organisers. The response to a question about why and what motivated them to support the AQE project was collected in one spreadsheet. The 103 backers volunteered their responses, mostly in the form of one or two sentences. My analysis of these 103 responses identified three major themes. While the majority of Kickstarter campaign supporters, like its core developers team, were often technologically-aware enthusiasts interested in social technology, there were also many who were driven by a common concern for the planet, or for their own welfare, and who were looking for technology that could support their struggles. The first category would be the already mentioned technologists involved with the development of social technologies, as these examples illustrate:

> *E16: I'm a London-based UX designer who is interested in using pervasive technology to help improve people's lives. This seems like a very interesting experiment.*
>
> *E17: I am a semi-retired instrumentation technician living in the high desert of N.M. I have a Pachube feed now just for hobby purposes. Interest in air quality is a just concern with keeping the planet liveable. I would be interested in setting up one of your "eggs".*

As comments indicate, the project's hands-on, experimental, open and DIY approach, seemed to appeal to skilled people who saw an opportunity for their skills to be applied, even in retirement or in their free time. It is worth noting that some of these supporters, exemplified in E17, indicated their knowledge or use of the Pachube platform, further suggesting ties with a broader DIY and open hardware community. Likewise, the project was attractive to technologists and activists involved in some already existing communities or education projects, as illustrated by the following:

E18: I am an architecture student working for a non-profit community design center called building community WORKSHOP. I am leading an energy education initiative, and we are working on a plan to implement home energy metering and feedback at a community scale. I think air-quality goes hand in hand with efficient energy use and "healthy neighbourhoods". We are working on solutions to bring forward the benefits of sensor technology in making educated behavioural choices related to building energy performance in low-income communities (with limited access to these technologies).

Example 18, however, can also be seen as one that exhibit several motivations as it blurs the backers own technological know-how with that of education initiative that is concerned with helping a low-income communities to make educated behavioural choices. The latter, while resonating the general IoT discourse also highlights the second theme that emerged across the motivation sample. The second theme involved day-to-day activists who in general are interested in the common good, the health of common resources, and in activism as such. While expressing global concerns, supporters in this group were more often concerned with local issues. Examples can be drawn from comments such as:

E19: Hi, I live in London England and always wonder just what I'm breathing in, in this unnatural world we live in!

E20: I want to know what kind of air quality we have here in Valparaiso, IN, with Chicago being just upstream from us and all.

E21: Hey - I live in Atlanta, GA - Would like to monitor air quality.

E22: I am interested in the 'activist' angle - data that compliments or supersedes that provided by established power structures.

The third theme that emerged encompassed people with existing health problems who were looking for the tools to explore their own environments and thus to tackle or self-manage concerns driven by their own or their family's health.

E23: Hi, my interest is in the levels of pollen, mold and humidity as I am asthmatic.

E24: I am in Switzerland and they smoke so much here, they also use a lot of chemicals, from paint to the oils for heating..... I am sure this has affected my breathing these last years.

E25: My children have developed asthma symptoms, and I would like to know how the air quality is to see what correlation can be inferred from the data.

E26: My family lives several miles from the Rhode Island Central Landfill, which was never an issue until around September of this year, when foul gas odours began emanating from the landfill and spreading far beyond the landfill's boundaries. Sometimes the smell is so pronounced and gag-worthy as to induce headaches and nausea. I have a hard time believing that a gas so noxious could possibly be benign, and I'd love to contribute in any way to help measure and map air quality in our community. Plus, I'm a geek and just love the idea of a connected device like this.

As these examples corroborate, the growing community involved in supporting this project were situated predominantly in Europe and America. Furthermore, it seemed to engage citizens in both urban and rural settings, interested in both indoor and outdoor air monitoring. Some of them had some other group affiliations, some did not. While these are comments are from only a few members, they illustrate well the three general themes, as well as how often overlapping their interests and motivations were. The Example 26 is another good example that illustrates these overlapping motivations of people who on the one hand have some technical knowledge, and on the other hand have a particular concern. In this particular example the motivation is stimulated both by an activist concern, living next to a landfill and by his personal health concern – the experience of headaches and nausea. These three broad categories and the same underlying concerns echo across the community discussions I have observed on and offline, before and after this campaign.

This would suggest that many who joined the AQE Kickstarter campaign not only felt connected with the community's ideals and proposed objectives, but also exhibit alignment with the initial community in terms of the three key motivation frameworks, their communicative competence, and the use of the rhetorical framing of IoT and citizen science contexts. For example, Example 18 touches upon the idea of behavioural change that such sensing technologies could encourage. The idea of behavioural change echoes across many other conversations I have observed, as well as in the broader IoT context. This not only suggests the participants' perception of the technocratic and social framing of the IoT debate, but also how energy efficiency and similar issues of sustainability are located within the framework of the citizen science network. Example 22 similarly highlights an issue of concern that can be found in our study, both in terms of the original group of AQE advocates and the extended AQE network, that of power relations. As noted already, by drawing parallels with established data sources, or criticising the shortcomings of existing air quality measurement stations or their network density, there seems to be a common distrust of 'official' data. Such a position is often employed, in both identification and motivation framings, by this, now extended, community of AQE network participants.

Furthermore, like the original developer's team, this now extended AQE network was made up of geographicaly-distributed participants. Analysts of Kickstarter campaigns (Agrawal et al., 2011; Mollick, 2013) have noted that there is an observable geographic component to campaigns. While this study did not have access to the time data of each pledge, the ethnographic data suggest that there might be a correlation between the number of supporters and the origin of a campaign. On Aug 10, 2012, Simone Cortesi, a biogeographer and an OpenStreetMap Italy founder, mapped out the locations of Kickstarter backers, illustrating the locations where the eggs would be despatched.

8. Screenshot of the Kickstarter backers map by Simone Cortesi (August 10, 2012)[188]

The largest supporter base of 461 backers was in the USA and Canada, followed by 180 backers in Europe. The map also shows how wide the appeal of the project has

188See original here: http://shop.wickeddevice.com/wp-content/uploads/2012/08/CortesiMAp.jpg been as it has reached places such as New Zealand, Australia, Korea, Taiwan, Georgia, Estonia, Island, Israel, Brazil, Hawaii, to name a few. However, the map only covers 714 backers instead of the total of 927 pledgers[189]. From the data of this map and the observations conducted on conversations in other online spaces, it appears that it was not so much the geographic nearness but rather mental ties and community associations that motivated backers. To further the Agrawal et al. (2011) suggestion, I would argue that the large number of USA supporters could also be explained by the fact that the Kickstarter platform itself is USA based, requiring backers to pledge in dollars, a factor that could possibly prevent a broader international appeal.

5.3.4. The Network Device

5.3.4.1. 'A plastic box with electronics'

The AQE Kickstarter campaign was a significant milestone in the development of the AQE community network, not only in terms of fundraising goals but also in terms of outreach and the launch of a consumer-ready network device. This section will examine in more detail the materiality of the AQE device and the logic that governs its outputs. Following the logic of Kitchen and Dodge (2011), the AQE device could be described as a networked sensory codeject as it not only senses its environment but also delivers sense data to the network in real-time.

189It should be noted that data retrieved from the Kickstarter campaigns site do not correlate with the data in the map developed by Simone Cortesi. Kickstarter data shows that there was a total of 545 backers from the USA, 75 from the UK, 46 from Canada, 42 from Australia, 32 from Germany, 20 from Netherlands, 15 from Switzerland, 14 From France, 14 from Spain, and 8 from Italy. This would further suggest that the data on the Kickstarter platform is closely associated with the payment method rather than the actual geography of the person itself.

9. The AQE in a physical setting (2013)[190]. Image by Ilze Strazdina.

In AQE V.1 there were two parts to the system, or not one egg but two eggs. The sensor itself was placed in the outdoor egg that transmitted the sensor data wirelessly to the network unit, which was set up inside, connected to the Internet via the Ethernet. Both eggs were powered by static power adaptors[191]. There was a small fan at the base of the eggs to ensure an airflow to the board. The microelectronic SD boards for the base station and remote unit, Sensor Interface shield, Power/UI shield and add-on boards for ozone and volatile organic compounds (VoC) were custom designed by WickedDevice[192]. All basic V.1 AQE kits had three sensors attached to their sensor shield: a DHT-22 temperature and humidity sensor, a MICS-5525 carbon monoxide (CO) sensor and a MICS 2710 NO_2 sensor.

The firmware, designed by WickedDevice, ensured that the AQE kit was ready to use, and users could plug-and-play the device with ease. However, as people started to use the first eggs, some issues arose. A blog posted by the WickedDevice developer on April 4, 2013, highlighted the issue of the compatibility of all these elements[193]. In response to concern about incongruent data being reported by AQE and the natural response of the sensors, the developer conducted an experiment with a reference circuit. The results showed that elements of the hardware, such as the fan, and elements of the software, such as the heat algorithm, had a significant influence on sensor data output. Subsequently, further algorithmic solutions were applied and firmware updates implemented.

190I purchased my AQE on May 2013

191There were also discussions on the production of mobile battery powered units. However, the overall consensus in the community discussions led to the prioritisation of the development of static units.

192All hardware design files are available on: http://solderpad.com/vicatcu/

193For full details see: http://shop.wickeddevice.com/2013/04/16/air-quality-egg-research-findings/

During the prototyping workshops there were discussions about the LED signals that could report the state of air quality. In the final version, the LED lights signalled only the state of the egg itself, i.e. if it was on, connected and transmitting data. The UI shield had a capacitive touch sensor, a switch that could be activated to ensure human interaction. Both hardware and software components of the egg were modular, and all codes were open and published on GitHub, an open source code repository. Depending on their level of technological understanding, users could either “plug n play” the AQE, or tweak it for specific case requirements. The device had an egg-shaped body made of moulded plastic. Like its hardware and software parts, the body was prototyped and developed in an open manner by two recent contemporary design graduates: Albert Chao and Eulani Labay. 3D design files, for both 3D printing and injection moulding, were published on the community's wiki site.

5.3.4.2. On the Calibration Debate and Care for the Device Network

The most pressing question that has lingered around this project was that of the data accuracy and how sensor measurements created by the device could be evaluated. While I will discuss the questions related to data later on, in this section I will attend to the question of calibration. To expand on the method and approach this community chose to handle this most salient of questions, this section will examine the discussion threads and conversations between AQE community members on matters of calibration. The record of these discussions can be found on a number of AQE community online spaces, most significantly its wiki space[194] and google group[195].

In applying technology to any given natural phenomenon, there are two fundamental issues that are of concern. First is the question of measurement[196], i.e. what it is that is

194See discussion on groups Wiki site: http://airqualityegg.wikispaces.com/Data+Quality

195The discussion on calibration methods and approaches was ongoing. The analysis here focused on the time between December 2011 - December 2014. The full conversations can be accessed here: https://groups.google.com/forum/?fromgroups=#!topic/airqualityegg/9a0GoVzRjLo

196As noted, AQE V1.0 (2012) had two pollutant sensors, CO and NO_2, plus temperature and humidity. However, the AQE was built as a modular unit, thus other sensors could be added. (It measured, as each pollutant can be measured in a variety of ways, and in what units[197]; the second is the question of calibration of the measurement tool. From the start, the groups chosen use of off-the-shelf sensors signalled uncertainty in terms of the desired accuracy. On a mailing list, the conversation started with suggestions of a number of ways that the calibration method could be developed. Example 27 demonstrates one of the earliest suggestions made on this matter:

> *E27: In the UK it is a legal requirement for cars to be tested annually. The equipment for that testing is available at every MOT test centre. One possibility might be to take along one's egg to the MOT and use the test's data report as a means to at least know a single reference point.*

The DIY approach suggested in Example 27 received many responses. One of the predominant suggestions was that of scale-free calibration for which some high-end calibrated sensor used by a known source could be used to compare the data created by an AQE, as suggested in Example 28 by use of the term 'official data':

> *E28: I think we could calibrate the eggs using the official data... and perhaps it is not necessary to quantify that there are xxxx ppb NO2, but just qualify that NO2 level is low, medium, high or very high.*

Other methods suggested including the use of 'Blind Calibration' and 'Network Calibration'. Blind Calibration, as discussed by Balzano and Nowak (2007), offers a means of making sense out of raw data read from sensors with no calibrated source[198]. They propose an algorithmic solution, a "novel automatic sensor calibration procedure that requires solving a linear system of constraints involving routine sensor measurements" (Balzano and Nowak, 2007:2). The group itself put the 'network calibration' approach forward. It is explained in Example 29:

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should be noted that today (2017) AQE V.2, $PM_{2.5}$ and PM_{10}, O_3 and SO_2 are also integrated).

197The concentration of NO_2 is most commonly measured in micrograms per cubic metre of air ($\mu g/m^3$). The AQE device measures CO and NO_2 in ppb (parts per billion), the other possible way of measuring air pollutants. The measurement is defined by national standards; for example, the US EPA standard for NO_2 is based on ppm, while the European one is based on milligrams; however, there is a standard way to convert readings from $\mu g/m^3$ to ppb.

198They applied the term *Blind Calibration* to "automatic methods for jointly calibrating sensor networks in the field, without dependence on controlled stimuli or high-fidelity ground-truth data".

> *E29: "network calibration" aspect: using the size and distribution of a large sensor network to improve on the sensing quality provided by its constituent devices. Picking up on a few discussion threads I suggest four phases/strands:*
> *1. Collect known system limitations (how good/bad are our sensors really?)*
> *2. Collect recommendations for metadata to collect ("traceability")*
> *3. Review potential network calibration models, pick one*

These suggestions, one could argue, illustrate a practical way forward; however, soon into the discussion of both these methods, a comment was made about the lack of supporting sources for these approaches:

> *E30: There is no useful theory that anyone has put forward or a technical paper identified that supports the concept of "Blind Calibration" for a simple stationery sensor - that is making sense out of raw data read from sensors with no calibrated source. There appears to be a lot of wishful thinking.*

The problems with 'network calibration' similarly lacked technical papers to support this approach. Up until today, there has not been a network-wide calibration, and most of the AQE V.1 units used the default settings. The key argument to this approach was made by the community organiser, who wrote in the statement published on the AQE Kickstarter campaign site:

> *E31: A note on calibration: Impossible. We cannot build a consumer-focused product that requires regular maintenance/calibration of the sensors. Moreover, off-the-shelf sensors like we are using do not come calibrated, and so we would incur significant expenses to attempt to calibrate them after integration, only to still have the problem of re-calibration later on. Therefore, we can, and will, only look at trends in the data. Smart people, I'm sure, will find savvy ways to interpret this data for us, match it up with calibrated datasets (government or scientific institutions may be able to provide these), and /or learn things we never thought we would learn due to the sensor resolution, update frequency, and resolution we aim to achieve.*

However, this did not stop the community members from sharing their findings, thoughts and processes on this matter. In fact, over 90% of all discussion on calibration took place after the Kickstarter statement was released. As Examples 32 and 33 illustrate, people continued to contemplate and experiment with calibration, to draw meaning from the raw sensor data, thus contributing to the community's shared knowledge pool.

> *E32: Yes, I think in the long term calibration is very important to this project. While I am not an expert at calibration, I am involved with a project that will be testing some Sensaris Sensors against Alberta Environments reference method to see how the data compares for NOx. I had suggested that we test the AQegg sensors as well. I believe that we need to know what the sensor's data is saying, and how it correlates to a reference method. What is the variance, drift, etc.?*

> *E33: Based on the number of sensors (and data) that will be available and the fact that data will be 'raw' (uncalibrated, etc.) this looks like a very interesting project and challenge for applying pattern recognition techniques in order to either identify patterns (based on location of eggs, sensors used, etc.) and/or classify air quality (based on user estimation, correlation with other data, etc.).*

Furthermore, later discussions offer an overview of what impact the calibration argument might have had over time. Example 34 is taken from a post published in 2014. It can be observed that the initially chosen approach was frustrating some members who had been part of this community from its inception:

> *E34: When the AQE project launched, its modus operandi was: "build first, ask questions later". To me, that was an exciting approach given how little the community knew about commodity metal-oxide and light scattering sensors. Given what we now know 2-3 years later, the build first, ask questions later approach seems questionable.*

A year later, in 2015, three years after the launch of the project, questions about data reliability were still coming up on many threads of the discussion list. Examples 35, 36 and 37 represent a conversation that was happening in the 24h time window.

> *E35: Hi, I am interested in buying an AQE for a community project in Oxford about air quality and environmental monitoring. The reliability of the data is important for us as it could drive decisions about investments in the community.*

E36: Hi, Short answer: you would need to calibrate it. Also, experience shows that it is unreliable for monitoring nitrogen dioxide air pollution. Try something that works! Other people have also found that the sensor used on the AQE (which is the same as the Citi-Sense[199]) is unreliable.

E37: It's important to remember that the Air Quality Egg project in many ways pioneered this field, and a number of projects that used the same sensor technologies (right down to the manufacturer's part number) followed in our wake. I think XXXX claim is correct in spirit, though not entirely accurate technically. Metal oxide sensors have a high degree of performance variability, they have a high degree of co-variance with temperature and humidity, and we have never had the capacity to calibrate them and account for all those factors in software (and have never claimed to), but with our current processes we do our best to at least normalize their responses. With the right facilities at your disposal, one could certainly put the effort in to characterize her personal sensors' responses and modify software to use those results. I want to take this opportunity to look to the future. We haven't been talking much about it, but we haven't been resting on our laurels. Quite the contrary, we've been actively working on a next-generation Air Quality Egg (v.2) that uses fundamentally different sensor technology (that is factory calibrated) in hopes of putting some focus on better data quality.

As these examples demonstrate, there is a complex set of issues involved in performing the calibration process accurately and making it applicable for each set of objectives. Example 37 was a fragment from the mail sent by one of the WickedDevice developers. As he notes, the AQE V.2 was launched with a more accurate, factory-calibrated set of sensors. It was the discussion on sensor calibration that emerged as the most valuable legacy created by these early participants of the AQE community network. Not only did their shared findings provide a remarkable source of information, but also signalled a network-wide engagement with the issue of air quality and the methods of calibration. Thus, I would argue, the initial community's decision not to calibrate the sensors before there were shipped transferred the responsibility of meaning-making to the network of new egg owners. That not only brought the issue of calibration, and with it the number of ways in which meaning could be derived, to the foreground of the egg owners but also encouraged the open discussion observed.

199Project info can be found here: http://citi-sense.nilu.no

As highlighted in section 2.2.3. there are a number of challenges involved in the development of IoT systems. The same goes for the calibration process as the complexity of issues goes beyond the method of calibration. In any technological setting, faults can occur frequently, at different levels. While it might appear that the device is still monitoring, the data it transmits might be incorrect. Kingsly and Kaviyarasi (2014), in a context of Wireless Sensor Networks, noted that:

> *In general, fault occurring in sensor network can be classified into two types. They are function faults and data faults. Function faults normally refer to abnormal behaviours of the sensor nodes, and this leads to network failure or breakdown of a node. Whereas in data faults, nodes behave as normal nodes, but they sense wrong information when compared to other nodes in the network. (Kingsly and Kaviyarasi, 2014:899)*

The AQE mailing list discussions similarly drew attention to the issues of faults, and numerous problems with 'any type of' calibration were identified. Those included not only technical, i.e. those associated with hardware and software applications or processes, but also social and socio-economical ones, such as regulation standards in different countries. Here is a list of a few problems identified:

> *'The sensors will degrade over time.'*
> *'The devices don't always perform the method correctly. They get out of whack;.'*
> *'In developing software, one sets up procedures.'*
> *'Calibration is only valid for a limited time.'*
> *'There are different definitions of calibration.'*
> *'I realized air quality limits differ from the US to the EU, and elsewhere in the world.'*

The material properties of the device and its sensors are rather fragile technologies that require repair, recalibration and maintenance. “Caring for the environment requires caring for the machine” as put by one of the AQE peers. While some in the AQE network community account as technically savvy, many lack the skills to sustain the required care. Thus, technical expertise and its distribution is not only a burning question in the context of this project, but also the wider social context of the future IoT. The issues of social context and its values were discussed within the broader Pachube community. The 'faulty node issues' were highlighted, for example, in the case of the radiation network in Japan, as they surfaced during the network data visualisation process[200]. In Japan, members of the community, alerted by the irregularity of readings from one such node, contacted the owner of the node only to discover that it was affected by falling raindrops. Such power of many, as this example suggested, can have a positive impact for the 'community network approach' argument and its practical values. However, such application of network monitoring as a whole would require network-wide analytic tools currently unavailable for the AQE network. Furthermore, as scholars in this field have noted, what many citizen science projects, be they individual or group projects, often lack is professional input from experts that could help them to maintain and service the devices and their sensors (UWE, 2013; Austen, 2015). To overcome these impediments, further thinking into how to support the sustainability of such community-led device networks, in terms of social and technical maintenance, would be required.

5.3.5. AQE Data and Related Considerations

The issues related to device calibration are tightly linked with that of data accuracy. As scholarship in the area of citizen science continues to advance, doubts about data accuracy and reliability are a key reason why many scientists remain reluctant to use data collected by devices in citizen care (Crall et al., 2013; Riesch and Potter, 2013). This section, however, will turn to explore data-related matters in the network context, and how the current dependency on a platform-centred approach further undermines data production, access and desired interoperability. As has been pointed out, the AQE sensor would not exist nor have any impact in isolation from the ‘web or networked fabric of Pachube’ (McCue, 2012:para 4), its online data repository. The Pachube data platform, and any other equivalent data hosting platform, is a key player in the overall story. Not only is it at these online repositories where raw data gets converted and displayed, it is also where the data is archived and made available. Other important matters, such as data security and services providing for data interoperability, are also conducted by the data hosting platforms, thus adding an additional layer of complexity to the overall process, however seamless it might appear.

200At the 4th IoT London Meetup, designer Haiyan Zhang presented her work on radiation network visualisation. She described a case of such a faulty node that was sending data ‘off the beat’, and how the data gave a ‘clue’ that there might be some problem with the node.

In the case of the AQE device network, the sensor data (however accurate) is pushed through the Internet to an online data repository, where it can be accessed directly through the Pachube platform interface[201]. With the launch of AQE V.1 and V.2, a new, more integrated system was adopted. The new AQE network interface at airqualityegg.com permitted owners to register their eggs by entering a serial number[202], adding a short description of the egg, submitting its location, and marking the indoor or outdoor exposure and elevation from the ground. After registration, the four basic AQE data streams were displayed. This site, however, did not provide the user with any further access to data streams or refined search options, nor did it support user communication. Its rather static nature acted as a register and interface to the AQE network[203]. After registration, the data streams were sent to the Cosm (Pachube) platform[204]. To access one's data streams here, the owner was required to register as a user of the COSM (Pachube) platform. As previously noted, during one year, the platform itself went through numerous stages of redevelopment, renaming and, most significantly, changed its ownership. Throughout these changes, the AQE users, wishing to create an account on this platform were supported fairly well. Today, while existing account holders can still access their AQE V.1 data streams here, the overall project and AQE V.2 have moved to a new data hosting platform at opensensors.org. This, one could argue, while supporting the community's ongoing needs, could also jeopardise AQE network data interoperability.

A platform provides account holders with infrastructure-specific features. These, in turn, enable or limit options users have to access, input or export data, etc. Similarly, the effects, both in terms of the back-end or interface level, can be felt following platform upgrades, redesign or change of ownership, as in the case of Pachube. As noted already, on COSM (Pachube), account holders can upload their data, access their raw data files, observe their data streams in a graphic format, and manipulate viewing options on a time scale of 1 hour, 24h, 1 month, 3 months, 6 months and 1-

201 An example of the communication code between an AQE V.0 device and the Pachube server during its prototyping stage can be seen in Appendix X. Using the PUT method, the request is sent to Pachube, at the time built in the REST architectural style. The data is updated every 3 to 5 seconds. On a device level, data codes and raw data can be accessed via the Arduino integrated development environment (IDE).

202 The SN is uniquely assigned to each egg.

203 Browsing (June 2017) the sites interactive map for information provided, it is notable that many Eggs stopped updating around the fall of 2013.

204 All V.1 and V.2 eggs are already preprogrammed to send data to chosen repository.

year. The two screenshots (see Appendix IX image 1 and 2) taken on April 7, 2012, represent the changes in the graphical interface during the period of transition from the Pachube to COSM platform identities. As the screenshots illustrate, in AQE V.1, the 'feed' had a provision for six data streams[205]. Besides temperature, humidity, CO and NO_2 sensor data streams[206], there was also a provision for the interactive, user-activated 'button', and the Air Quality feature, intended for add-on sensors or a correlated air quality index; neither of these features was ever properly realised[207]. The interface design modification[208] and the new display of COSM feeds were celebrated as an improved version of the data graphs. In the new graph, the visible measurement scales were removed, and more interactivity was added by presenting readings in response to a cursor move. Through this process, however, the previously available 'Add a Trigger' button, a way of supporting data owners' manual metadata inputs, was moved into the deeper level of the developer's toolbox. The "Add a Trigger" button in the original design represented that unique character of community involvement, involving the active observer that was talked about in E3, whereby human input could be added to note something, offering an opportunity 'to think about the moment' and add the human observation next to the data streamed by the device. As the COSM platform was finally incorporated into Xively, the data interface was redesigned again (see Appendix IX image 3). In this final version, both streams for the interactive buttons were finally removed. In their place, new data streams were added displaying the electronic resistance of the sensors[209]. This might

205Each data 'feed' on the Pachube platform required an API Key, within which numerous data streams were contained.

206The measurements presented here displayed data as follows: CO in ppb, NO_2 in ppb, temperature in degrees Celsius, and humidity in a percentage.

207It was never clarified what data was pushed in this category. There is one reference to this sensor in an email posted on Feb 29, 2012. There, Joe Saavedra wrote: "Also, I failed to mention that in fact nothing is hooked up to the "Air Quality" sensor." On April 26, 2012, Charalampos Doukas published his study on data, and the correlation between the Air Quality sensor data and other sensors on the board. There, he stated that he had no knowledge of what the actual explanation of the Air Quality datastream was (and what the values meant); however, his study indicated that only humidity levels seemed to affect the sensor readings for the Air Quality feature. See his post here: http://blog.buildinginternetofthings.com/2012/04/26/pattern-recognition-for-the-air-quality-egg-part-two/

208In a separate study of visual ethnography, in a paper I presented at the IBG Annual International Conference at the Royal Geographical Society in 2014, I argued that the visual changes portrayed by screenshots (see Appendix VIII) represent not only the processes of Pachube's final commodification, but could also be seen, in a way, as visual gentrification, in which first the pink, then the bright yellow design interface build in HTML (both signalling fun, experimentation and openness) were turned into the blue, sterile Web 2.0 style interface for the leading IoT cloud computing provider. Or, in other words, the choice of colours and design approaches not only represented the standardisation process of this platform but also altered the perception and meaning of it for its users.

209In ohms, marked as 'sensor raw'.

be insignificant; however, the removal of the interactive button, I would argue, is just another sign of how the original visions of the platform developers were crushed by the looming paradigm of automated data management.

Another significant change was time access. With Pachube/Cosm, data could be tracked for a period of one year; in the Xively version, the maximum time was marked as 3 months. This rethinking of the length of time data would be displayed subsequently leads to a question regarding data storage and ownership. For how long data is stored? For how long is it accessible? Who owns this data and what does it mean to be an owner of AQE datastream? As we have observed in this study, the AQE community members have expressed the desire to use the data for comparative studies over time. To do this, two elements are required . First, the AQE device needs a considerable life span. Second, the data host must be willing to host data for a given period of time.

As noted already, the sensor lifespan is rather limited. For example, the screenshot from the Xively site (see Appendix IX image 3) displays data from the two last sensors active on my AQE V.1[210]. As this screenshot shows, my AQE V.1 finally stopped working in March 2015, three years after the start of the project. This not only raises the question of the lifespan of an IoT-type of device, but also raises questions about sustainability. How is the device lifecycle managed, how is maintenance conducted and how often does the device need to be updated, both in software and hardware terms? And what happens to the device when parts of it stop functioning? In the case of the AQE V.1, its open source nature at least offered me an option to recycle some of its parts.

The other rather complex question is that of data ownership. In the context of the AQE project, there are certain issues that need to be brought to the foreground. In terms of ownership of data hosted by the commercial, privately-owned COSM/Xively platform, it has been stated: 'You own your data and you can export

210Since the launch of this project, I have monitored my own AQE V.1 that was set outside my window for purposes of this ethnography. I have done very little to interfere with its working. Besides occasional reboots, I have not updated or recalibrated the sensors in any way. Over the past three years, I have watched how, one by one the sensors, and even the cooling fan, have stopped functioning.

your data at any time.'[211] However, data produced by the AQE devices are not linked through individual feeds to the egg owners' accounts. Feeds get aggregated in an AQE network account. In other words, the data created by the AQE belongs to the AQE network rather than the individual egg owner. There are pros and cons for such a setup. This means that individual egg owners cannot, in any way, interfere with feed metadata, for example. But it also means that for someone trying to make sense of the overall network or build some on-top applications, the resource is consistent, in terms of tags and its metadata.

At the time of the Air Quality Egg development (2011-2012), one Pachube/Cosm data corpus analysis noted: “Many Cosm feeds have not been annotated with a sufficient degree of detail. Even the scale and units of measurement can differ within groups of sensors that observe the same physical property” (Dittus, 2012:45). Likewise, the study pointed to the lack of clarity and uniformity of metadata that supported the data streams. However, the study went on to conclude: “This result does not put in question that there may be a potential ability of such community sensor activities to yield data suitable for building large-scale spatiotemporal models, but it clearly indicates that such data aggregation is only possible when the metadata supports it, and currently Cosm metadata is too heterogeneous” (Dittus, 2012:46). As such, one could argue that the launch of the AQE network, with its single point entry access, now ensures a homogenous approach to metadata and data management.

Data ownership is still a contested matter. However, as it was often discussed by the AQE project protagonists, the AQE network itself was a critique of the new data-driven world paradigm through questioning its meaning for collaborative economics. The AQE network data is open access data that permits and encourages other developers to build on-top applications, mashups and maps. Thus, on the one hand, the centralised AQE network data architecture can be seen as a necessary and positive solution to managing the otherwise decentralised network of AQE device owners. On the other hand, this centralised aspect is also its weakest point. As observed, once platform owners cease to maintain data or use a particular format, for whatever reasons, access and the subsequent interoperability of that data are disrupted. Thus, such a network data ownership model, where data is hosted by

211See Xively terms and conditions here: https://personal.xively.com/faqs/

privately owned platforms, may affect the value and sustainability of such community or citizen-owned data sets.

Furthermore, data platforms enable access to data and to data aggregation, from which further meanings could be derived. This, in turn, can lead to the data being presented as information or used as a political tool. This aspect often presents itself as the most problematic. As Examples 38 and 39 reveal, seeing the patterns of change in data is not enough, and further discussion is needed about what can be done with such data, or what actions one could take in response to such data. What are the philosophical and ethical implications of data-empowered global citizens? Example 38 illustrates concerns of one AQE user, while Example 39 raises more rhetorical questions expressed during the development process.

> E38*: My question is how can I interpret these numbers? My family is mostly asthmatic and this would indicate to us that we should move right away... not trying to be alarmist but since we aren't totally sure what we're looking at, some info would be helpful. We want to know the meaning of the data over time. Especially anything we can do to calibrate things so we can see changes seasonally.*
>
> *E39: After all, with air pollution, the origins are not always clear; your agency as an individual is very little and CO2 is not to argue with on a local neighborhood scale. So you install an air pollution sensor and the air is consistently very bad (like it is and will be where I live). I know, now I can see it for it for myself. So what? What can I do? Move? Where to? Sell the house and not tell the new buyers why I move? How ethical is that? Having data in itself does not bring knowledge or change. Only agency to act on that data will bring information, knowledge or change. Without a 'how to do' kit that goes with the tech (is it not plain tech push otherwise?) about possible community action, counter activities with plants, herbs and planting certain vegetation community garden style, boycotts of products of companies that produce traceable pollution in an area, making pollution visible by putting up real blockades with wood and blocking intersections, cough consistently within and with a whole street for a week ... I don't see why it would make sense to have this data.*

As in other observed communications at the time of this study, these examples raised questions to which finding an answer is an ongoing challenge for anyone engaging with such network-empowered sensing tools. Moreover, engaging with data and negotiating the discussion on meanings created moves the discussion further into the realm of citizen science, where answers can be deliberated on in a collective manner. As time has passed, the new initiatives have furthered what I will call the legacy of the AQE project.

5.3.6. The Legacy of the AQE Project

The legacy of the AQE project is twofold. First, there is the subsequent continuous development of technology, with the AQE V.2 set of devices having been developed and sold by WickedDevice. In its version 2, the AQE device comes not as two separate egg units, but as one USB-powered unit with onboard sensors, wireless connectivity and an LCD display, all integrated into the same egg-shaped plastic body. There are also numerous sensor modulations available[212]. All sensors are now calibrated at the sensor factory (SpecSensors) and individually tested in a ‘zero air’ chamber. Building on previous learning, developers have adopted more accurate temperature and humidity sensors. In a recent [2016] comparative sensor performance study, conducted by South Coast Air Quality Management District researchers, three Air Quality Egg V.2 sensor devices were run side-by-side with Federal Reference Method (FRM; EPA approved) instruments measuring the same pollutants. The study found that overall, the three Air Quality Egg V.2 sensor devices which were tested, each one measuring CO and NO_2, “were reliable, (i.e. no down time over a period of about two months) with a high data recovery of ~100%, but showed substantial intra-model variability”. Furthermore, there seemed to be “a complete lack of correlation between the CO and NO_2 sensor data and the corresponding FRM data,” noting that further “chamber testing under known target/interferent gas concentrations and controlled (temperature and relative humidity) conditions are necessary to fully evaluate the performance of the three Air Quality Egg V.2 units.”[213] Nevertheless, the study conducted on the $PM_{2.5}$ sensor

212Today (2017), the WickedDevice shop offers a number of devices with different sensor modulations, each available for $240. Furthermore, the GPS Package for $65 and Offline Data-Logging Package for $30 are also available for those interested in the mobile deployment of devices in the absence of a WiFi network.

213AQMD test preliminary results retrieved on 1 August 2016 from http://www.aqmd.gov/docs/default-source/aq-spec/field-evaluations/air-quality-egg-v2_co-no2---field-evaluation.pdf?sfvrsn=0 showed that the Air Quality Egg V.2 not only correlates well with the FEM $PM_{2.5}$ data, but also outperforms other available sensor devices on the market, such as the Dylos, AirBeam or MetOne.[214]

There has also been a change in terms of AQE data hosting. The AQE V.2 network data is no longer stored at Xively. Data today is hosted and stored at OpenSensors.io[215], who, as the WickedDevice site states, 'are committed to keeping data open and free'[216]. As with the previous host, the AQE data owners should first open an account with OpenSensors to access their data via API. The improvement of the devices and their data architecture are ongoing [217].

Today, there are countless air quality monitors available on the consumer market, both for indoor and outdoor air monitoring. Some offer comprehensive packages that include not only multiple sensors, cloud data and service bundles but are also combined with baby and home security monitoring systems. However, the unique character of the AQE still seems to stand out, both by competing in the consumer market as well as offering something for more engaged citizen science projects. In one recent (2016) blog[218] review of the 10 best air quality monitoring devices for home electronics consumers, the AQE device was highlighted as one ‘For the Environmentalist’, noting its offering to monitor NO_2 pollutants. In one comment left by an Amazon.com consumer, the AQE citizen science contribution was brought to the foreground:

> *E40: 'In addition to monitoring carbon monoxide (CO), Nitrogen Dioxide (NO_2), humidity, and temperature of the area in which it is placed (indoor or outdoor), our readings are added to a worldwide data set. I love the citizen science element!'.*

214A full list of AQMD tested devices and test results can be downloaded here: http://www.aqmd.gov/aq-spec/evaluations#&MainContent_C001_Col00=2

215Code for integration available here: http://shop.wickeddevice.com/2015/11/23/embed-able-real-time-air-quality-egg-charts-from-opensensors/

216Migration of data completed on January 8, 2016.

217The latest firmware update was pushed to the AQE V.2 network devices in early May 2017, promising more “coherent and sustainable data structure by publishing messages to device-specific topics, thus relieving the OpenSensors servers of burdens created by a previously inefficient workflow created by publishing data on a separate topic for each sensor type”. Community discussion on these and other technical topics can now be found at the WickedDevice forum located here: http://help.wickeddevice.com/

218See full review here: http://www.jenreviews.com/

The AQE concept legacy, likewise, has manifested itself while reviewing the broad range of currently available air quality monitoring devices on the market today. One of the leading smart air pollution monitors available on the market, developed by Beijing-based company Origins[219], is called LaserEgg. As there is no visible similarity between the shape design of this device and an egg, one could anticipate this to be a conceptual legacy of the AQE network project, and its egg-shaped design.

The second point on the AQE legacy is its uptake for local projects that have sprung up around the edges of the network. There are a number of community-led local AQE deployment projects that have published and shared reports on their findings and processes. In the USA, the Citizens For Clean Air group, in the Grand Valley in Northwestern Colorado, run experiments with five eggs installed at different locations across the valley. Not only have they published and shared their findings with the AQE community[220], but have also been featured on a local news channel[221]. In spring 2013, 17 AQEs were distributed to residents in north-west Portland, Oregon. This project, initiated by one local activist from Neighbours for Clean Air in Oregon, was supported by Intel Labs, who took on the project to gain experience of low-cost sensor application, data visualisation and its impact on residents, in terms of user awareness of their data[222].

In 2013 in the UK, Network for Clean Air[223] conducted a citizen science program with communities of place and communities of interest. As part of this project, they worked with three owners of the Air Quality Egg in order to compare air pollution measurements taken by analogue technology (gas diffusion tubes) and their Air Quality Eggs for nitrogen dioxide air pollution[224]. In London, the *Breathe Heathrow* (2015) project distributed AQEs among residents of the Heathrow airport area, and

219See company website here: http://originstech.com

220Referencing here two documents published by Grand Valley community members: 'Frequently asked questions about the Air Quality Egg Project in the Grand Valley' and 'Monitoring Air Quality In The Grand Valley: Assessing The Usefulness Of The Air Quality Egg' by Nelson (2015).

221The TV episode is accessible online. Retrieved on 10 August 10 2016 from www.westernslopenow.com news website.

222More information of this project can be viewed here: http://www.intelfreepress.com/news/big-data-makes-invisible-air-pollution-visible/5667/

223More information of this project can be viewed at http://www.cleanairuk.org

224A presentation by one of the AQE hosts can be watched here: https://www.youtube.com/watch?v=-8A_1Ra0Gkc as a result succeeded in informing broader policy debate and the subsequent delay of airport expansion in South East England[225].

The AQE has also served as an accessible education tool for air quality monitoring, having been used for numerous school science projects. It has been harder to track these youth-oriented projects as they are often set within school environments. However, there is enough evidence online suggesting that the AQE, with its appealing design and open data access, has enhanced the conversation about air quality within educational environments. In such environments, the AQE has been discussed from many angles, be it design, marketing, environmental or general studies.[226] In Munster, Germany, for example, six students from the Anne-Frank-Gesamtschule Havixbeck and the Anette-von-Droste-Hülshoff Gymnasiums Dülmen worked together with the developers from MexLab on the Air Quality Egg in Münster Project (2013). Students learned how to analyse the setup and function of the AQE, how to edit the AQE Wikipedia page, and to create a film demonstrating how to use the AQE[227]. Furthermore, some data on experiments conducted by young individuals can be traced online, either on the AQE mailing list[228] or in other online spaces[229].

Some members of the AQE community have developed AQE reading and geo-tracking maps[230], browser extensions[231] and further evaluations of device

225This was a temporary project developed by OpenSensors.org and postgraduate student Natalia Oskina. Read more on its impact on Open Data Institute’s blog. Retrieved on August 10, 2016, from https://theodi.org/blog/a-year-in-open-data-breathe-heathrow-informs-policy-making

226A presentation by students in the technology marketing department on how to introduce the AQE to Australia (2014) can be found here: https://prezi.com/s9wytoqvrdlp/copy-of-air-quality-egg/; Design course assignment report can be found here: https://static1.squarespace.com/static/54c2080de4b08b9c092408a7/t/55656a4ae4b0f94763ac7b2d/1432709706251/FinalDocAssignment3-MakingSenseofData.pdf;

227Read more on 52north project's website http://52north.org/component/content/article?el_mcal_month=2&el_mcal_year=2009&id=282:wps20

228A father of a schoolgirl engaged the list with a discussion on a possible hypothesis for her school science class (2012). The transcript can be viewed here: https://groups.google.com/forum/#!topic/airqualityegg/DJSxn6ZlSO0

229For the report, see Rand (2013) on environmental education projects for schools. The project of a young science activist made for the Science Fair Project in Washington DC (2013) was published in video format, and is accessible here: https://www.youtube.com/watch?v=mmWSE9twUi0

230During the winter semester of 2012/13, the bachelor students at the Institute for Geoinformatics developed modelling and visualisation of AQE network data. Their code can be found on GitHub.

231The founder of FTP software, John Romkey, wrote a Chrome browser extension that can be downloaded from his personal blog. Retrieved on 10 August 2016 from https://romkey.com/code/air-quality-egg-helper-browser-extension/

performance[232]. Others have applied and perfected community-driven approaches to air measurements similar to the AQE community while using other types of devices[233]. More recently, a design project on AQE interfaces called "Illuminating Air Quality" (2016) has received funding support from a new business incubator in Ithaca, New York, to further tackle the user interface solutions.

These latest actions, recorded years later, show that processes started by such citizen science community groups might not have an immediate effect, but could deliver value as time goes on. However, it can also be noted, that all these projects are of a temporal nature, which would suggest the AQE and its framework is a good tool for starting conversations.

5.4. Conclusion

This chapter aimed to address the question of how, through the process of collaborative production, the community of early IoT adapters set about developing one of the early examples of a sensing networked device, and generate the subsequent network of its users. Through this collaborative and open process, they not only created the space for such an activity but also a space for tacit knowledge production and distribution. Likewise, the creation of the AQE device acted as a way of conducting an institutional critique, through its modes of sensing and by opening up science to citizens through engagement. The intention of this chapter was to show the social and institutional mechanisms at work when the open source and grassroots community addressed a real-world problem, using rapidly evolving, novel technology. In particular, I have shown how this community, through engagement with a number of hybrid spaces offline and online, went about the process of prototyping, production and distribution, and how it responded to the difficult problem of calibrating readings from low-cost sensors.

232More information of this project can be viewed here: http://www.earth.org.uk/note-on-Air-Quality-Egg-REVIEW.html

233Madrid based *The Data Citizen Driven City* project used AQE to set up *The Device Library* and citizen device *How To* database.

Measuring and assessing the effect of air quality is, as many studies have confirmed, not an easy task. Research in health studies has shown dependency on the method used and bias from predictions due to algorithms that correlate between predictions and the actual levels of pollution. Thus any findings are seen as estimates (Currie & Neidell, 2004). These studies would have been based on data measured by air quality monitoring stations run by established government agencies. As this study has indicated, the data generated by these stations have limited scope (mainly due to their low distribution density), and thus, to question government data by the use of 'citizen sensor devices' that promise sensor access to very local environments became one of the prime arguments for this community. However, the study also noted that data created by such citizen-led initiative still lack accepted scientific standards[234]. Nevertheless, as I argued, the emergence of the IoT frameworks has enabled, in this case, community development of air measurement devices that in turn have created a space for discussion and practical application. This has led to the creation of a shared knowledge distribution base, from which empirical learning and further initiatives can spring.

Furthermore, this part of the study argued that the difficulties faced by these developers were unique not only to this project, but were deeply rooted in the current limitation of technology and the broader discourse of science versus citizen science. By focusing on this early stage of IoT development and this community's aspirations for the development and utilisation of open IoT network data, I have shown how this community, in their process, raised more questions than they could possibly find answers to. By engaging with the framework of consumer capitalism, they created an open source product, now widely available on the market. Thus, the legacy of the project is not only its precedent and the space it has opened up. What should be taken into account is also the assets that they have created. Thus, and I argue in accordance with those who have suggested that such citizen-driven projects have the potential to bring society closer to science (Gollan et al., 2012; UWE, 2013), by creating a widely available open source product, they also contributed towards improved scientific literacy, now possible through engagement with such devices.

234This, however, is changing as in December 2017, the Department for Environment Food & Rural Affairs (UK) acknowledged that in “the last decade there has been rapid growth in the development of low-cost sensors for air pollution measurement” (2017:para 1), and published their advice on the use of 'low-cost' pollution sensors.

The AQE project could be also seen as a successful contribution to an effort to create an instance of what Bauwens called the global commons paradigm. Kostakis and Bauwens (2013), in their projections on how the move towards collaborative commons could take place, describes global commons as “alliances of ethical enterprises that operate in solidarity around particular knowledge commons” (Kostakis and Bauwens, 2013, para 5). However, it could be argued that in terms of achieving a collaborative model, in particular in terms of collaborative ownership, the project might have failed as it failed to produce economic value for the whole network. In turn, this, I would argue, should be put in the context of the ongoing nature of a project that is facilitated by the very existence of this new consumer device, thus spreading its applications and growing its user base. The provision of an affordable, open source air quality measurement tool and community knowledge resource base could well contribute to the overall economic value of a particular local enterprise.

One aspect that needs further scrutiny is the socio-economics surrounding such initiatives. Issues include necessary support systems and organisational structures. The AQE development at its outset was supported by the Pachube enterprise, financially and technically. However, it was driven by the enthusiasm of its key players. The temporary nature of such support, I argue, leads to the withering away of overall network potency. How can structural forms be fostered for the future sustainability of such citizen-led networks? The sustainability of such air monitoring networks should be of prime concern if there are to be future attempts to integrate their data into an overall air quality monitoring system or to make their data interoperable, accompanied by relevant metadata and human feedback. These are particularly important questions to resolve in the context of data that are collectively created and shared. This study suggests that the network logic and collaborative culture have shown great potency in how accessible technology and open data are created and managed. Further research and discussion would be an opportunity to address some of these issues.

6

'LET'S NOT TALK ABOUT FRIDGES!' THE EMERGING DATA PARADIGM

6.1. Introduction

It is often assumed, in media and popular discourse, that IoT is all about the future connectivity of smart devices and, in particular, home appliances, such as thermostats, lights, coffee pots and refrigerators, or smart devices, such as cars or wearables. However, as this part of the study will explore, inside the growing IoT industry, the largest promise of the IoT has been the data deluge connected things will bring about. This part of the study is primarily based on an analysis of speech data, collected during the two-day semi-public event that took place in June 2012, just three months after the launch of the AQE Kickstarter campaign. The Open IoT Assembly, the last major event organised by the Pachube community and their associates, gathered about 100 participants[235], and was filled with keynote presentations, discussion groups and panels.

From the outset, it seemed to be a great opportunity, in a public debate, to form an understanding of the key concerns of this extended group of early IoT adopters and explore how the common meanings were being derived. This seemed a good starting point as the event was set up as a public deliberation to 'share visions for what an

235The event attracted over 100 participants from different fields: system and interface design, architects, makers, developers, hackers, ethnographers, bloggers, researchers and a wide variety of entrepreneurs. Many of these represented smaller groups, enterprises, academia and the social sector. There was also another group of participants. As in the late 1990s, with the Internet, when open source conventions were 'anxiously attended by venture capitalists, who had been informed by the digerati that the open source movement is a necessity' (Terranova, 2000:50; see also Leonard, 1999; Terranova, 2004), there were representatives from the business world, multinational technology companies and a few venture capitalists, who similarly wondered where the profit was in Open IoT projects.

"Open Internet of Things" would look like'[236] and lay down the principles for an *Open IoT Bill of Rights*, suggesting a framework for story-telling and collaborative decision-making. The initial *Pachube Internet of Things Bill of Rights* was proposed by Usman Haque and Ed Borden in 2011, and later published in issue 28 of *Volume*, an international quarterly magazine for architecture and beyond. In this issue, dedicated to all matters concerning the Internet of Things, Haque and Borden explained their motives and thoughts behind the need of such a bill:

> *It's an attempt to build up consensus around what we urban citizens should expect of the data that is being gathered, and will be gathered more insistently, by devices, sensors, and monitors in our high-growth massively networked cities. We propose the Bill earlier this year to our global community of 'internet of things' enthusiasts and we did so not because we conform to all structures but because we believe we should conform to them. We wanted to foster conversation around what rights the Pachube community believes are important so we can make sure to build them into our real-time data brokering system. (Haque and Borden, 2011:156)*

Further on in the article, they argued that data ownership would continue to be one of the defining issues of the coming decade, and that there were only two ways it could play out: either by controlling people's access to their data, or by unlocking data from the silos in which they had been restrained. Aligning the Pachube community's response with the latter, they suggested that it was not enough just to open up the data; it was much more important to develop platforms for participation, data-orientated applications, and to encourage public and citizen engagement with data crafting and the processes of defining what data is, how it's collected, and explaining what is done to it.

If, as explored in the previous chapter, the AQE project was one such open citizen engagement opportunity, the Open IoT Assembly was an opportunity to extend the conversation towards other industry players. Although the IoT industry, at that time, was an emerging field, the participants of the first Open IoT Assembly clearly were at the core of this discourse. This boundary between the IoT discourse insider and outsider was exemplified by the discourse specific vernacular, in this case an ongoing joke, often referred to both in physical and online space. Just one hour after

236 Documentation of event and related issues can be found on: https://www.postscapes.com/open-internet-of-things-assembly/

the start of the assembly, the following tweet was posted in the backchannel; this not only highlighted one of the most popular signifiers of IoT discourse but also, through its negation and choice of modality, signalled the vernacular recognisable to those belonging to the inside.

> *at #openiot. time from start to first mention of internet fridge: about an hour.*

During the two-day event, the mention or not of the 'internet fridge' became a reference point or measure of the success of one or other discussions or presentations. Within this group, to be a discourse insider meant not talking about the connected fridges. The Internet-connected fridge represented the PR talk, was seen as being in bad taste, or in other words not being a very serious or meaningful conversation. For example, another tweet later read:

> *Home document being pulled together for #openiot (no mention of internet fridges!) (yet) - do sign in!*

Although the participants of the event were discourse insiders, I would argue that the event sat outside the dominant industry space. Indeed, by adopting techniques from the creative fields of art and design, such as manifestos and a communal decision-making process in an assembly, the event was an intervention in the dominant space of industry. This alternative position was also highlighted by the very first tweet published with #OpenIoT handle by the Open IoT Assembly account, created on April 3rd, 2012. The tweet drew attention to a manifesto published by British graphic designer Ken Garland (1964) and its 1999 revision that urged designers and visual communicators to reconsider the position of their work and trade in a world saturated by commercial messages and advertisements:

> *The First Things First Manifesto is quite a nice starting point for the #openio #https://tinyurl.com/yaa8mlvy*

Like the designers of the last century, who wanted to expand the scope of a debate shrinking under the pressures of consumerism, Open IoT advocates fully understood the design at the core of these new systems, and how their designers were the manufacturers of future realities. The Open IoT assembly was an embodiment of the desire to act upon the world, to create an intervention into the technological and social flow of the IoT discourse, and its proposed Bill of Rights was designed to create a framework for a more socially aware approach to IoT development. However, taking the debate beyond the perceived borders of the Pachube community meant contestation of these ideas.

In the process of two days of deliberation, the community's position and its maverick starting points, proposed in the form of the Bill of Rights, I would argue, were coerced into a current day neoliberal[237] form of 'statement' and 'invitation to participate' that adopted the more viable language of legal and business frameworks (see both documents in Appendix XI). In the initial Pachube IoT Bill of Rights, there were eight clear statements. The first two emphasised people's ownership of data, expressed as 'people own the data....', while the latter six stressed the rights people should have, expressed as 'people have the right to....'[238]. In the final statement, however, there were five areas of concern marked in terms of goals and provisions which re-articulated the manifesto points in more managerial terms. For example, the simple manifesto statement 'People own the data they [or their “things”] create', in the final statement read 'Data ownership should remain with the Licensor'. This simple comparison of two sentences illustrates well the change in the frameworks evoked, and with it the divergent perceptions of the actors entangled in this social contract. Furthermore, the move from the human-centred aspect of 'rights' of people to a more abstract 'data'-centred universe, observed in the case of the final statement, brings to the foreground the evolving notion of 'data' as the capital in a future IoT-driven world paradigm (McCann, 2013).

As noted already, from the outset, my intention was to seek out the key concepts and concerns of those who had gathered, and the ways in which agreements were reached through public discussion. As I started the analysis of all the transcripts, a data corpus made up of 69,024 words, my initial focus of this study shifted. During the

237 Here I use the David Harvey definition of neoliberalism he describes as 'a theory of political economic practices that proposes human well-being can be best advanced by liberating entrepreneurial freedoms and skills within an institutional framework characterized by strong property rights, free markets, and free trade' (Harvey, 2005: 2).

238The original document is published on: http://www.theinternetofthings.eu/internet-things-bill-rights first examination of the transcript, about 30 words were identified to represent the principal concepts that appeared across different discussion groups and speech events. Those were concepts such as: commons, city, climate, data, Internet of Things, home, open, public, privacy, space, sustainability, etc. Each separate corpus was then searched for these words. The numbers of occurrences, broken down by corpus, helped me to identify the most dominant concepts that concerned the participants of the Open Internet of Things Assembly (See the data matrix in Appendix XII). As the focus of discussions was the preparation of an Open Internet of Things Bill of Rights, my initial hypothesis was that prominent in a discussion would be concepts such as Internet of Things, rights and open. However, the top five most used words were data (904), open (234), license (195), Internet of Things (136) and public (118). These were followed by standard (83), rights (82), privacy (69), space (63), and commons (59).

While the Open IoT paradigm was deliberated across contexts such as home, city, community, body, access and time, licensing, and citizen science, the discussions, as this initial analysis showed, converged around the phenomenon of data and its meaning in these diverse settings. The word 'data' was the single most used word during the two-day event. On further scrutiny, I identified around 250 unique word markers associated with the use of the word 'data'. After a closer analysis of the meanings and context of this word in speech acts, three major context categories were identified. These were human, other than human, and technical contexts. In the following analysis, these contexts will be examined, and the subtly different perceptions influenced by these will be discussed in relation to emerging data-related themes, such as data relationality, its perceived materiality, value and ownership. Thus, taking into account the historic time of this event, by talking about the visions of an Open IoT, the assembly also contributed to what has now become Open Data discourse[239].

Scholars in data studies often point to the origin of data and its historic meaning in the context of statistics, where it is presented as neutral in its nature (Gitelman, 2016). Daniel Rosenberg (2013:37) argued that data, as in the past, has “no relation

239It is worth noting that only a few months later the Open Data Institute was launched by Sir Bernard Lee and Sir Nigel Richard Shadbolt. Gavin Starks, one of the Open IoT keynote speakers, became its first CEO.

t o truth”, and it is precisely this rhetorical nature of data 'that has made it indispensable'. He argued that because of this “it is tempting to want to give data an essence, to define what exact kind of fact data is” (Rosenberg, 2013:37). The concerns and use of data are nothing new and it has been appropriated over time by many industries and fields, including economics, science, geography, health and the humanities (Brine and Poovey, 2013; Garvey, 2013; Krajewski, 2013). However, the introduction of network technologies and use of computation have changed the scope, scale and availability of data or, in other words, data science has moved from being a data-poor to a data-rich environment (Miller, 2010).

The discourse around data has evolved and numerous new research fields in this area have been established. Besides general data studies and Big Data studies, there is now a Critical Data Studies (CDS) framework that firmly establishes data as a form of power, and as such scrutinises “all forms of potentially depoliticized data science, to track the ways in which data are generated, curated, and how they permeate and exert power in all manner of forms of life” (Iliadis and Russo, 2016:2). CDS holds the notion that data is inherently social, with all its social data problems. Scholars in CDS argue the field requires social solutions, and greatly increased data literacy is necessary. The origin of CDS can be traced back to the same period, 2011-2012, when this study was conducted. It was around this time when two young social media researchers at the Microsoft Research labs articulated the fast-growing data expansion and used the term Big Data (in capitals) for the first time in an academic article[240] (Crawford and Boyd, 2012). Subsequently, in 2014, they set up The Council for Big Data, Ethics, and Society that was founded by the National Science Foundation and is now leading the current debates in the field of CDS.

While this part of the study hopes to contribute to this debate, it also aims to uncover the perceptions of data in an IoT context. As will be explored, in 2012 the use of the term in language had already become pervasive. Thus, I will argue, the concept of 'data' has acquired an informal logic, and its employment in expressions signals the concept that postulates one that calls for what Geertz called a thick description. As an

240In their polemical article *Critical Questions For Big Data*, Crawford and boyd defined Big Data as 'a cultural, technological, and scholarly phenomenon' that rests on the interplay of computation and algorithmic technology, analysis of large data sets and mythology: the widespread belief that large data sets offer a higher form of intelligence and knowledge (Crawford and boyd, 2012:1).

anthropologist, Clifford Geertz applied the term thick description in the context of ethnography of human behaviour. Geertz argued that the thick description, the term he borrowed from philosopher Gilbert Ryle, is necessary to explain both the behaviour and the context in which it was set in order to make it meaningful to an outsider. For Geertz to understand the culture of a people was to understand the 'webs of significance' that man has spun for himself - another metaphor he borrowed, this time from sociologists Max Weber (Geertz, 1973:5). It is this understanding of thick description[241], in Geertz's perspective, that argues that thickness has culturally specific significance, and I will use this in unveiling the changing nature of the data concept in the perceptions of the event participants, and its significance in the context of the IoT debate.

6.2. Data Context Frames

Humans are always in composition with nonhumanity, never outside of a sticky web of connections or an ecology[of matter] (Bennett, 2004)

As the initial analysis of the data corpus identified, there were three main contexts in which the word data appeared: technological, human and non-human. While I will consider these contexts across the overall study, this section will address each of these contexts separately to highlight the frameworks in which they appear, and ways in which they are thought about.

6.2.1. Technological Context

As noted already, much of the IoT discourse was developed within a technological context. These technologies and perceptions of them are complex, and most likely will grow in their complexity over time. For example, in a broader context of the network and information society, what we can and cannot do today is governed by the technologies and the underlying codes and principles that govern them (Castells,

241Rather than the use of a thick concept in ethical philosophy (for example by such philosophers as Bernard Williams) who argued for the use of the term thick concept in cases where concepts are loaded with both, descriptive content and its evaluative meaning.

1996; Becker and Wehner, 2001). This, in turn, shapes our perception of the world, our everyday experiences, and language itself (Axel, 2006). The same, I would argue, in the context of the IoT discourse, could be said about data and our perception of it. Data today not only inhabits the technological realm, but is also shaped by it. This *shaping* of data and its meaning by its technological context can be observed in the analysis of speech acts and the frequent reference to its technological framework.

Pachube was one of the earliest examples of cloud-based data platforms, and also the instigators behind this two-day event. Thus, it might not be surprising that while all the discussions and keynote presentations had some reference to the technological framework and particular vernaculars of this context, the largest number of these were used in a presentation of the Pachube founder, Usman Haque. His keynote presentation not only shed light on the inner workings of such data platforms, but also gave insights into his own motivations and revealed a broader context of surrounding industry. Haque engaged his audience by giving them a rich, contextualised view of the Internet of Things. A good example here is the example U1, the few sentences he uttered while showing a real-time image of Pachube/Cosm data fire hose[242] on the projection screen.

> *U1: this is all coming in **real-time**, these are **data points** coming in from all sorts of **different devices**, they are **categorised or uncategorised** as you can see there. So there are 'bout 30 million **data points** coming in every day. And it consists of **time series data** but it also consists of **contextual data**, **metadata**, to do with its **geo-location**, how the **author described it,** the **tagging**, what have you.*

The list of different namings gives an overview of some of the most common terms and concepts used when data is addressed in a technological context. While such naming is used in any data-related discourse, be it scientific or in a context of census data, it is the changing scope and temporality that brings significance here. “This is all coming in real-time”; he pointed to the real-time phenomenon that data now inhabits. Use of the 'moving through space' metaphor reveals not only the space data is occupying, quite independent from the physicality of a space here and now, but also highlights the data movement in time. The scale and scope of data are brought to

242 'Data fire hose' – a vernacular for real-time data streams.

the foreground by the sheer number of data points performing that movement at once: 30 million. In other words, the technological framework he wanted to present here is not only a platform but it is also a data-rich environment.

Haque's rhetorical strategy, appropriated here, was designed not only to engage his audience directly with the complexity and contextual nature of IoT but also to emphasise that it works because of the confluence of the human and the technological. As he highlighted the human actant present here, he aligned her role with that of an 'author' that 'described it'. When observing the projection of the fast-moving image of a Pachube fire hose, ordered in lines of categories, it was hard to follow the words describing each of these data points. Some words flashed by and read: 'relative humidity', 'outside temp', 'basement', 'indoor', 'OMP', 'CMP', 'counts per min', 'house', 'light', 'power', 'Geiger', 'current cost', 'solar', 'open', 'TEMP', and so on. By juxtaposing the running image with naming multiple data types, Haque was bringing to our attention the complexity involved in data naming, mining, sorting, categorisation and what a reading of 'data' brings to the discourse and to science at large. It is not only that more and real-time data is now available within its technological framework; it is the entanglement with the human presence that not only brings further complexity to the subject but it also justifies the reason for its being there in the first place. Tackling the broader vision of the IoT paradigm with questions such as ‘Why are we so keen to instrument the world?’, Haque argued for what he called the 'teaching /learning paradigm' in which the desire to measure the world out there comes from the human desire to ask questions and develop hypotheses so that subsequent strategies can be formulated. As he put it poetically, it is our “desire to give the planet a voice” rather than the idea of there being some objective universe out there that should guide the implementation of the IoT.

Observing the use of vernaculars in his speech was most compelling. For example, his call for 'stepping beyond data' not only revealed his visionary narrative at the very time when most IoT data, and in particular Big Data science, was taking its shape. Linguistically, the use of multiple spatial movement metaphors in a data context was similarly thought-provoking. While being the head of a leading data platform, Haque maintained here his other position, that of independent researcher, architect and interaction artist – trades that he mastered before the development and launch of

Pachube. His presentation at the OpenIoT Assembly, in front of many industry representatives, was a call to sustain the open and human-centric approach to the future development of the IoT.

His application of technological vernaculars to non-technological contexts was similarly noteworthy. While making a point about the importance of people in this discussion, he reasoned that 'our bodies are the most complex sensors that we know of. Our bodies are able to aggregate all this complex information to do with humidity, sound, light, temperature, electromagnetic fields, social relationships, Twitter feeds and actually make some kind of sense of it', thus bringing to the foreground the emerging metaphor of human = sensor + processor. In the IoT paradigm, it is not only the brain that does the processing, the previously-used computational metaphor, but also our bodies, which are feeling and sensing mechanisms. This framing, while sustaining the computational analogy, suggests the possible end of the dialectical mind and body rationale, and the emergence of a more holistic perception of ourselves. His speech was intensified by expressive gesticulation. By stretching both hands, he imitated the movement of what, in the next sentence, he called 'incoming data'. Continuing in this expressive manner, the following utterance (see U2) was intended to move his presentation forward to the next point he wished to make, that of a need for appropriate tool development to tackle the issues of complexity and data heterogeneity.

> *U2: Because ...very few of you out in audience.... and very few people out in a city ...are so bedazzled and so confused by this* ***incoming data*** *that they are not being able to deal with it. Everyone goes through this process of making sense. And the same is true, of course, for non-human actors. The trees and animals who co-habit with us.*

It can be seen that, in this utterance, Haque appropriated the use of the vernacular 'incoming data', most commonly used when talking about data in a technological context (see U1), in a human context to describe our ability to cope with simultaneous information received by our bodies every second. Such use of the vernacular in a human context was intended to draw parallels between a human’s and a machine’s ability to make sense of the complexity of the world. Likewise, it was a tool to reiterate his key pledge - to embrace the complexity rather than opt for the continuation of a reductionist attitude and its desire for data homogeneity, which he described as a 'sort of fallacy of Internet of Things'.

The presence of data and its technological context were often used in speech acts of the assembly participants. Undoubtedly, it was the nature of this gathering that amplified the frequency of such a context and the variety of vernaculars used. While in technical contexts of the IoT data is perceived as an independent entity, its character is seen as fast moving, temporal and complex, and in relation to other data out there. In the next section I will argue that when data is referred to a human context, it is not only relational to a human self but also often discussed in terms of its value, ownership and emotional attachment.

6.2.2. Human Context

When analysing the use of possessive pronouns in the speech acts such as 'my data', 'their data', 'your data', 'his data', 'our data', the presence of a human context is made apparent. However, when speakers use the term 'my data' there is also a lot of ambiguity and a merger of numerous realms performed. For example, ‘my data’ could relate to the data of the device, data created by the body, by the person’s presence in some location like home or city, or data created by the clicks of the mouse. This presence of 'my data' belonging to numerous realms was poetically illustrated by another keynote speaker who, while arguing for the necessity of openness to achieve the desired data flow in a connected IoT realm, also brought to the foreground these multiple 'my data' collection points.

> *U3: So, this flow, so, me, getting all* ***my data*** *from my body, going through and in my home, taking care of things I have there, going somewhere, being on the move, in this sort of city space, that line is being built this moment. And I think the question is now, will it be open or will it be closed.*

As the speaker pointed out, these are different moments in time at which different 'my data' presence can be observed, and that are collected by numerous entities within the connected IoT paradigm. Likewise, there are numerous relational modalities. ‘Me getting all my data from my body’ suggests an active entity in control of the data created by his body. While ‘me going through somewhere, being on the move’ signals passive control over how or who creates the ‘my data’, and its relationship to the third and fourth party involved, and a subsequent number of data collecting devices. Thus, as I will argue in this section, the use of possessive pronouns often indicates an emotional attachment to 'data' that is perceived to be created or owned by the individual.

In a discussion about what the Open IoT would mean in the context of the body and closed body technologies, there were numerous instances of possessive pronoun use. While many speakers were particularly concerned about the use and misuse of data created by the body, what was often referred to as *self-data,* the meaning of pronoun use (for example, the use of 'my') shifted between different data types and associations. In cases where the possessive pronoun 'my' is used, this was perhaps most obvious in the following example. One of the participants remarked that she would like to add a discussion point to the access and time category, which would guard her rights to 'my data' in the following utterance:

> *U4:...if* ***I put data*** *on COSM should I get alert and know who is retrieving* ***my data*** *or I ask COSM to ….as a user I retrieve* ***data*** *for two weeks* ***of my body..****.*

The use of the pronoun 'my' in this utterance is rather ambiguous as it is framed in two different contexts. She speaks about 'my data' that is already on a COSM data platform and 'my data' that is retrieved from 'my body', as the second part of her utterance shows. These imply two different meanings: in the case of example U3, 'my data' from 'my body' is associated with the notion of body, thus most likely referring to the measure of heart rate, temperature, etc.; in contrast, the 'my data' on COSM would be a data stream in a certain format, with certain access rights, and safeguarded over a certain period of time. However, in both cases, her emotional attachment seems to be identical as will become apparent in the next example. As this conversation about the use of data on data platforms continued, someone suggested that a log should be kept of all 'my data' used and then e-mailed to the owner of 'my data'. In response to that, the speaker argued that she:

*U5: '[didn't] want to receive a log of hundreds of users of **my data** and not know how it has been used'.*

Here, the speaker clearly thinks of data that is already somewhere other than her body and is already used by 'hundreds'. While at the same time indicating her distress of 'not knowing' how it is used, the speaker also signals how that data being somewhere else is very near to her persona in emotional terms. This emotional attachment to the 'my data' that is somewhere far away was by no means unique to this one example but could be observed on several occasions. If we try to speculate on a definition of what 'my data' really means in this saturated field of actants, an emotional attachment seems to communicate a clear property of 'my data'. What is a measure of my care? Do I care about this data or that data?

Further on, this leads to another parameter of this discourse. The private versus public and broader discourse around privacy. As the next example illustrates, there is a clear perception that 'my data' has both private and public elements to it. Likewise, from my observations, speakers seem to attach kindred emotion to their data in both realms. In the following utterance the speaker clearly distinguished this by locating 'my data' in a public realm:

*U6: I talk about **my data** that is public.*

Once more, it is not very clear what the speaker means exactly by 'my data' that is public, but by making the distinction between two data types, the speaker seems to signal possibly different levels of care or, in other words, emotional attachment. The utterance is taken from a conversation about data publishing, access, and the need for data anonymisation[243]. We could presume that she is speaking about: a) data streams on some data platform; b) data other than her ID; and c) data of some sort of measurement. However, in her previous utterance this speaker suggested the necessity for anonymisation of 'my data' that is already public, which could indicate that there is some form of identification and association possible. Likewise, her concern for data in the public realm signals the speaker’s emotional concern for it, as

243Interestingly, the word 'anonymisation' itself has been created and used now broadly in the context of data studies, with the Information Commissioners office producing the code of practice for data anonymisation (https://ico.org.uk/media/for-organisations/documents/1061/anonymisation-code.pdf) well as the level of care involved. Hence, while 'my data' can be, and most likely is, in both the private and public realms, the emotional attachment expressed towards that data seems to be equally present.

Discussions about public/private realms were present across the two-day event, and a number of issues were highlighted. The complexity involved in separating the private data in the public realm, for example, can be observed in example U7, which shows what one participant in the discussion group about the Open IoT at Home named as 'the background' for the debate.

> *U7: I am sitting here and looking at you and I can see that you are married, how high you are, what colour your hair are...you can't keep that **data private**, right!?. So, great, this is just a background.*

As this speaker suggests, the physical presence of a person in a physical environment entails some aspects, most likely visible ones, of what is perceived as 'private data' being publicly accessible. Extending such discourse to the realm of the pervasive IoT framework suggests that not only is the IoT seen as a public realm, but also that some acceptance of such 'lack of control' should be adopted, or and that this is something that could be perceived as a new normality.

Over the two-day discussions, I observed how emotional participants often became when concerns were expressed about access or ownership of what was perceived to be 'my data'. However, it is worth noting that, within the context of a discussion group on body or self data, the speakers were particularly passionate. This was highlighted not only by the use of possessive pronouns, as noted already, but also by the extensive use of adjectives within this discussion group. Adjectives such as anonymous, sensitive, personal, private, particular, own data, etc. were often used. For example, the anonymity of one's data was brought up more than ten times during one 45-minute session. One speaker argued for a need for 'something' that stands between the data producer and data platform, suggesting that true anonymisation is not even possible as long as the process involves, as he put it, 'the notion of a corrupt system of administrators'. This not only suggests that, for this speaker, it is a human element of the system that corrupts its perfections, but it is also his belief that 'perfection' of the system can be achieved by technological means. To open his argument, he used a rhetorical question:

U8: Do we know that ***anonymous data*** *is in fact anonymous?!*

He closed his rather long argument with a suggestion that, in his view, this would reinstall trust in the system. He talked of a need for 'some kind of anonymisation mashing', which was followed by the sentence that brought his lengthy thoughts back to the personal space by the use of 'my data', with the adjective 'personal' to amplify its emotional importance.

> *U9: Needs to come some kind of anonymisation mashing that is non-corruptible in a process. And once we got that, then we are in a chain. But if you don't have any of that, then frankly I don't have any of* ***my personal data*** *up there.*

The emotional engagement can also be observed when speakers adopt second person possessive pronouns. By directly associating the abstract data with second person possessive pronouns, speakers employ more emotional appeal which indirectly communicates the perceived data value as having an emotional attachment. For example, in one of the keynote presentations, the speaker used the form of 'your data' to directly address the audience and enforce her point by making it relevant to every single listener.

> *U10: The best thing done for* ***your data*** *will be done by someone else.*

While such use of a more abstract configuration suggests less emotional involvement, it still indicates that some care is suggested. The rhetorical use of the pronoun 'you' can also be observed in the next example. Here, the speaker makes a clear distinction between the two data types, suggesting further different emotional engagement and levels of care possible for each type.

> *U11: We should separate the two categories. The* ***deeply personal data****, your health or something inside your home; and* ***data about you*** *in public spaces. I think it is a very general line, but useful.*

In the first part of the utterance, the speaker employs the use of an adjective phrase in 'deeply personal' to make an emotional appeal about data, expressing similar emotions to that of 'my data', as it is associated with more private matters and the person itself. To reinforce this emotion, she grounds her statement by giving a concrete example, such as health or home. In the second part of the utterance, she juxtaposes that with a more abstract 'data about you' that is out there in some abstract 'public space'. No further concreteness is offered. As both examples indicate, speakers apply the second person pronoun use in grammatical constructions to indicate different levels of emotional attachments, thus they are subsequent indicators of care.

The use of grammatical markers helps to recognise the speaker's perception of one or the other data type. As noted here, the use of the first person possessive pronoun best illustrates the strong emotional attachment that is different in its intensity when second person pronouns are used. Furthermore, the attachments expressed in the concept of 'my data' are often related to the perceived value of data, and are tightly linked to the issues of ownership. I will discuss the issues related to data value and ownership later on, but at this point, it is sufficient to say that not only is the human context of data often evoked in speakers' utterances, but there is also the presence of an emotional bond that can be observed in this context.

6.2.3. More Than Human Context

This section will trace the data sources mentioned in speech acts that are created by other than human actants. However, as will be seen, this realm does not exclude 'human' from the stuff of fabrication, thus I will argue with Sarah Whatmore (2006) and adopt what she calls the 'more than human' approach to the world. From such a standpoint, the material things all around us, like our bodies, animals, the environment, are indeed empowered by networked connectivity and become data-generating entities; however, they are also always in composition with a human entity.

Firstly, when looking for the presence of other than human actants in the speech acts, in transcripts of the first Open IoT Assembly, the first thing that stood out was how normalised the notion of 'thing' data had become in speech patterns and how, for these early adaptors of the IoT, 'any thing' and 'anything' was transmitting data. Secondly, as identified previously, for the subjects of this study, data often meant some kind of value, whether on a personal or social level, and data generated by non-human entities, similarly, were perceived as impacting the human context rather than the context of things themselves.

A sound illustration of this could be example U12, an utterance taken from the discussion about the Open IoT impact on a city context. Early on in their discussion, this group tried to work out what aspects of a city environment, in relation to data creation, should be tackled by open IoT standards, and what rights would mean in such a context. After a number of diverse statements on standards, rights and contexts, one of the participants suggested focussing the discussion on specific data types rather than talking abstractly about data generated in the city environment.

> *U12: I don't think we need to talk about data. The* ***types of data*** *may be... the more important question is about the origins, the group that creates it - have some moral rights?! With, maybe... initial component ...creates finances. In* ***citizen data****, there is lots of booty finance, which could be environmental studies, or it could be* ***traffic data****.*

This is quite an entangled utterance in which a number of streams of thought are uttered almost simultaneously. In the first part of the utterance, the speaker makes a link between different data types and the creators or groups of creators that are responsible for the installation of the data collecting devices. He then suggests that these creators should have some moral right. It is not clear, but most likely he is suggesting that data, like creative content, is created; thus, the device owners have a moral right to the ownership of that data, or, as he later corrects himself, its 'initial components', further indicating the acknowledgement of multiple phases in the data journey. In the second part of the utterance, the speaker turns to the value aspect of data, suggesting that in one form or another data creates value, either financial or social. He names two instances in 'citizen data' and 'environmental studies', signalling the context frame outside this speech act. By linking the 'citizen data' to that of 'environmental studies', we can assume that he is not talking here about the body data or personal data of citizens of a given city or state but rather about the phenomenon of the day, and projects such as AQE network. Thus 'citizen data' most likely in this context would be the data created by air quality or water pollution or any such sensor equipped devices that are installed, and looked after by the 'group' of concerns citizens.

For this speaker, these kinds of data, generated by devices that are installed and cared for by the citizens themselves, constitute one type of data. To conclude his utterance, he juxtaposes it with another type of data – that of 'traffic data'. Again, it is not clear what 'traffic' really means here as two conceivable readings are possible. One would be a technical framing such as traffic of data itself, i.e. how often the data is sent up, who and how often it is looked at or analysed, or included in any other data set. Or it could be data aggregated by the multiple transport movement data collecting devices, installed and cared for by the transport police, city councils or other such institutional parties. In the context of overall utterance, it can be assumed that the latter is the case here of, the naming of 'traffic data' in the context of the more expanded idea of 'citizen data', most likely signalling the dialectical or even the application of political framing. Thus, while data itself is collected about matters other than humans, such as air quality or transport movement, in this speaker's view, data types are thought of as being thoroughly in the human context. Further on, data types are most likely are related to the network of human and non-human interrelated data sources, generated both by material and immaterial things and information.

In a different example, one of the keynote speakers, arguing for data aggregation and interoperability, presented an example in which two different data sources of non-human entities were named. Here too, the benefits were conveyed in terms of human gain.

> *U13: You got some **transport data** and you got some **geo data.** Its only when you have both you can get to your bus stop. So more data is better!*

As with traffic data, transport data is most likely already an assemblage of a number of data files created by various data sources. Transport data could include information on the status of a transport system or a particular mode of transport, arrival and departure timetables, information on routes and fares, and so on.

Similarly, geo data could be drawn from a number of geographic information systems. Thus, the sources of both are most likely to be a combination of both physical sensor data and information generated by one or another management or mapping system. However, as this speaker suggests, the relevance and value of these data sets are measured by their effect on human actions in the physical world – 'you can get to your bus stop'.

As these examples show, the data generating non-human entities, their context and derived benefits are deeply entangled with the human realm and, as such, will most likely encounter the issues raised in the previous section. Emotional attachments, issues of data ownership and desired rights for privacy provisions are likely to be at the core of these systems. This entanglement and complexity of related issues can already be observed in the broader public discourse as more and more data collecting devices get introduced into domestic and public environments. For example, in the context of geo data usage for location-based services and online applications, privacy has been a major concern, widely discussed both in media and academic contexts (Cheng et al., 2014; Alrayes and Abdelmoty, 2016). Furthermore, as Whatmore (2006) suggested, the presence of more than human entities will shift the focus of our concerns from what things mean to us, to that of an effect, or in other words what affects us or what is the effect of one thing or another on ourselves, our body, our minds, our perceptions. Data in such a context not only becomes the carrier to an understanding of the world, but also the means by which we engage with the world, or if thought in terms of Merleau-Ponty’s (1962/2008) ontology, becomes the flesh for our being-in-the-world.

6.3. Metaphors that Shape Data

While the above section illustrated the three main contexts in which the concept of data is often articulated, this section will investigate how the perceived shape, form or even materiality of data is moulded by addressing the use of metaphors in a speaker's utterance. The analysis and construction of linguistic metaphors could provide an understanding of the conceptual workings of the mind and human cognition (Lakoff and Turner, 1987; Sweetser, 1990). The conducted search and analyses of verb use in relation to the word *data* revealed how much data is perceived as an object that humans create, act upon and, through that, claim ownership of it. Overall about 50 unique verbs were identified in relation to the word *data* used in speakers' utterances.

As has been argued, the greater the level of abstraction, the more layers of metaphor are required to express it (Lakoff and Johnson, 1980). Thus it might not be surprising that most creative metaphors, in relation to what can be done with data, were adopted during the keynote presentations that tended to illustrate more complex ideas and possibilities, and less during the speech acts within discussions of practical concerns and solutions. For example, in Usman Haque's presentation when he explained his own motivations for creating the data platform and for making it open for others to participate in, we can find an example of the active and creative human role in a data creating activity:

> *U14: There is often this kind of thinking that is was all about* ***making data public****, but actually for me it was about* ***making data****, it really is about this kind of capacity of people to conduct these experiments, in some cases to identify the patterns, or to create patterns, to identify things like ….or understand things like reliability of data, to go through that process of measuring so that they actually understand all these things that in other domains, scientists, for example, become very familiar with.*

In the first instance, Haque adopts a more abstract style when talking about an abstraction of some data that is there to be made public, while in the second part of the sentence he asserts the initial drive for creating data itself. As this was a motivational talk, the speaker further contextualises how, by an act of making data, one could access a realm of experience that otherwise would have been limited to a more scientific domain. His presentation was full of examples that encourage active position of the user as an agent as well as a number of metaphors from a range of fields. Some were, for example, 'making', 'plugging' or 'crafting' from the maker’s perspective (see U15) or later, when referring to the data platform, the use of the verb 'handling', associated with handling goods in warehouses (see U16).

> *U15:* ***Data is not just out there to be plugged*** *from some sort of objective environment but* ***data is actually there to be crafted****,*

> *impinged upon the universe while we* ***are crafting that data****, so that the act is actually the creative one.*
>
> *U16: At the moment* ***we are handling data*** *from all sorts of things: radiation, weather stations, pollution sensors, you name it.*

Another keynote speaker brought up another often used metaphor from a craft domain – that of weaving. Here, unlike in the examples above, where data is perceived as something like electric cable or uncountable goods, a data object is presented as multiple threads that can be woven together in numerous, unconstrained patterns.

> *U17: We have the possibility to* ***weave all data*** *together.*

As can be observed, the speaker has evoked the abstraction of 'all data' to hypothesise the vision of data interoperability propagated in an open data paradigm. The use of crafting metaphors points to the perception of data as something that has a fluid, soft structure, that can be moulded, shaped, in other words, changed according to needs or creative stirring. The metaphor of weaving signals a string like nature or long threads with an undefined beginning or end.

Maglio and Matlock (1998), discussing the use of the metaphors in the context of Internet users, identified a number of metaphor categories. The above examples could be placed in what they called trajectory metaphors. In their classification, they also identified categories such as user as an agent and Web as the agent. Similarly, in the context of this study, such metaphor use could be observed in the context of data. In the above examples, the speakers often appropriate the use of both the active and passive voice when referencing the data and its movement. This could be observed across many discussions. For example, in the following utterance U18, the speaker uses the first passive form that assigns agency to 'data' and then clarifies this by asserting an active human position while using the intransitive use of the verb in a sentence with no subject.

> *U18: you could say that* ***when data goes public****, i.e. it's not formatted. If data is not formatted, you can use it to write an API.*

As can be seen from this and previous examples, verbs associated with data as an agent often express movement, while verbs associated with human agents vary with different activities. For example, in a city group, the discussion concerned licenses and what it would mean to appropriate the creative works license to open the IoT domain. One of the speakers, who seemed to be working with existing data sets, explained his approach to current license use and appropriated verbs accordingly:

> *U19: That when **we using data** it is not always the same as a creative work. It's just a nice analogy from which to think from.*

This example clearly points to an active act of using existing data or a data set to create something else, i.e. further meaning that the user, an active agent, can make out of it. This could be due to the nature of this particular discussion group or profile of the participants, but there seemed to be many examples of this active human position that perceived data as an object that is there to be moulded, by either, for example, licensing it, or taking it from one place to another, as the following examples show:

> *U20: we need to find a way to combine law and license in a way that **we can license data***

> *U21: When you no longer can tell, it's like **I take data from** New York database to produce...*

Talking about how an Open IoT could change the building industry, another keynote speaker argued that there was a huge gap between the promise of new buildings in terms of green standards and the real performance of the buildings over time, after they had been used and retrofitted. An opportunity to trace information about a building's real performance would not only show how truly efficient the building was, but also would lead to improved knowledge about standards themselves. In his utterance, the speaker evoked a vision of data created by the building by use of 'that' as a determiner, while employing the modal and gerund.

> *U22: And then **we can start using that data** to change standards themselves.*

It should also be noted that in many examples speakers used pronouns in describing what can be or is done to data, as in the example above. It could also be observed that speakers often shifted between this more concrete form of owning the action to a more abstract form by replacing the first person with a noun; for example, people or user. At one of the Unconference gatherings on ownership issues, a speaker opened his presentation by bluntly and theoretically asking a straight question: "*What does it really mean: I own my data.*" This question was a response to the original Bill of Rights document. The speaker then followed by reiterating the first two statements of the initial Bill of Rights:

> *U23: One of the first things is that **people own the data they create**. People **own the data** someone else creates about them. And first time I read this I found it very contradictory.*

Further on, the speaker made an attempt to illustrate the contradiction between the two proposed statements and in the process shifted back from the use of an abstract noun to the use of the plural pronoun. Thus, the description of the process shifted between the agency of the human creator and the data as an agent that does something, while using transitive verbs.

> *U24: So the creation process implies the ownership. Then there is the next one that you get **somebody to create data** about somebody else, **data describes** another person …then person **owning .. that data** somehow....who is owning it in the end....every **data we create is about something or somebody else...***

The observable shift here might be related to the fact that one of the objectives of the event was to deliver a public statement and as this example shows, was often contemplated in response to the initially proposed Pachube Bill of Rights, and the use of language appropriated in that document. As will be discussed later, the issue of data ownership in the realm of the IoT is complex, and was repeatedly negated across the two-day event. However, as these examples also illustrate, it is the creation metaphor that is often linked to the concept of ownership. If the ownership issue is less of a concern, other metaphors are brought to the foreground. For example, in the following utterance the speaker talks about some abstract data and what governments do with that data.

U25: Governments ***do invest in data*** *and luckily these things are open.*

As examples U20, U21 and U22 illustrate, data in the context of active agency is often thought of in terms of making, doing, taking, etc. Example U25, however, talks about abstract data, and appropriates a metaphor previously associated with finance and investment capital, as an investment opportunity, pointing not only to a notion of value associated with data but also its growing impact in the sphere of the economy. The other often used metaphor in the context of investment is that of data mining, which not only signals data's perceived value but also implies a linked perception to the field of mining for physical goods such as gold or oil (Mortimer, 2011; Toonders, 2014; Bergström, 2016; Rohe, 2017). While it has been argued that data has significantly different properties than oil or gold - for example, data will never run out; its value increases with more connectivity, not just volume; or the fact that the cost of the copy of data is zero - the popularity of this metaphor is as notable as the 'fridge' metaphor is in the context of the IoT.

As my study has identified, overall about 50 unique verbs were used in relation to data. The metaphorical contexts varied between the already mentioned ones, such as craft and spatial, to other more technical ones that could be associated with 'information action', as identified by Maglio and Matlock (1998). Examples of this would be: sending data, transmitting data, pulling and putting data. Metaphors from a more conventional media sphere could be traced in examples such as capturing data, publishing data and releasing data. Vocabulary associated with office and management fields could be observed in the use of verbs such as managing data, sorting data, testing data, and selling data, while statistical management metaphors include logged, aggregated, and collected. There was also a significant number of verbs used to describe what we could identify as the realm of social interaction in the use of verbs such as talk about data, want data and sharing data for example, as well as references to the domain of libraries with reading data, protecting and caring for data.

If we further think about the perceived properties of data, it is worth noting that data often is about something or someone. This use of conceptual aboutness, can be observed throughout my study. In the following utterance the speaker uses the broad concept of 'data about my life' while actually making a point about ways data could/should be licensed.

> *U26: much* ***data about my life*** *is not very interesting ...() something becomes much more interesting if it becomes an information.*

In the sentence above, the speaker made the point that he does not mind the fact that information is shared 'about him' as long as it is not traceable back to him through the use of metadata. This not only shows that the speaker perceives 'data about my life' to be many unconnected bits of data, which he does not care about, but his emotions are aroused if and when these bits are interlinked with metadata or, in other words, it can be traced back to him. In the other example taken from the debate about privacy, while trying to make a point about different entities, spatial configurations and the complexity involved in identifying multiple levels of privacy applications, the speaker offered the following mental representation:

> *U27: But when you out on a street, you don't know what sensors are there, collecting* ***data about you.*** *There are practical problems, I mean, how do you inform public....*

As noted already, in a technical context, IoT data embodies a notion of movement. While in some cases the perception of data is articulated as a static mathematical entity, as in the case of 'data point', or a measurable entity, as in a 'piece of data', 'data streams' imply something that is more fluid, moving, or alive. Something that, most likely, has a known source, while its end or the length of it is far less well defined. Example U28 illustrates this water metaphor well, as it describes clearly the origin of data, while its use as an end point is open to interpretation.

> *U28:* ***...*** *but if I would* ***create my own data generating device****, the thing, I would own the software it was written in, and the only thing left* ***– the data stream*** *would be generative.*

The same perception of 'the origin' can be observed in another example where the speaker talks, most likely, from the position of the creator of a device, the data originator. He uses the possessive pronoun to mark the ownership of the origin and then narrates the process that leads to some 'unknown' data use, at some point in the future and most likely in some as yet unknown place, which he still hopes to control.

> *U29: I have this* ***single data stream, data is in raw*** *resolution but I grant the license to implement (), which helps me to control how that data is used.*

The concept of longitude and some starting point, that can be observed in a 'stream' metaphor, is also present in the concept of 'string of data'. Like 'stream', the 'string' metaphor involves the concept of something long and possibly endless; however, as it is most likely referencing the string concept in physics that represents the number of objects arranged in a line or a consecutive order of characters, it is not a movement metaphor but rather a generative object one. The third most referenced concept that could be classified as a trajectory metaphor in a technical context is that of 'data feed'. Like 'stream' and 'string', 'feed' implies some perceived beginning and enduring change in terms of space/time, and it can be observed in example U30, taken from the discussion about the final statement and points to be included in it:

> *U30:* ***Data feeds*** *should have human and machine-readable licenses attached to them. [Bits should know their rights.]*

The 'feed' metaphor, like the 'raw' one observed in example U29, is a food metaphor. As both of them are mostly used in a technological context this signals a perception of data belonging to the realm of the machine, in which machines are perceived as a sort of organic matter that is able to create or needs feeding.

As the scholars of the metaphor used in the context of the Internet have argued, many metaphors exist for technical reasons, i.e. ”they emerged due to the urgent need to give a name to things that did not exist previously” (Jamet, 2010:14). Many of the data-related metaphors have existed for a long time. What has changed is the context of the technological and network paradigms, and the observable perceptions of data movement. Furthermore, it can be observed that the movement metaphors appropriated in the IoT data context mimic the ones already appropriated in the general context of the Internet. For example, the Maglio and Matlock (1998) study of web user’s speech identified already noted trajectory metaphors. However, if their study showed that users are “moving toward information, rather than as if the information is moving toward them” (1998:6), then the movement in the context of IoT data is rather different. As seen earlier, speakers often use metaphors with a perceived point of origin moving outwards. Furthermore, data is perceived as being near the body, the noted 'aboutness' of data or the use of 'create' and 'make' metaphors, where the human or his device is the originator, the source of that data.

Similarly, as with the Internet, the water metaphor of a stream is often evoked. Jamet (2010) went at length to show how the metaphor of water represents the notion of vastness, magic, mystery, and even danger, and that nouns such as streams, flows, pirates, and verbs such as surfing were dominant signifiers of that. In the context of IoT data, however, a stream is the only water metaphor used regularly, suggesting a rather different reading of a stream as an orderly, even if uncontrollable, movement or flow. It is most likely that as with the Internet, as the use of IoT data becomes more common, the vocabulary used will stabilise. It remains to be seen if creative metaphors of crafts or social betterment metaphors from the library realm will endure or become overshadowed by those of the office and automation.

6.4. Deep Relationality

As already noted, the data is deeply relational. As seen in example U12 or in example U13, concepts such as 'traffic data' or 'transport data' are made up of a number of interlinked data sources. Similarly, in a discussion about the more-than-human context, data of non-human entities are deeply entangled with data in the realm of human activity. Furthermore, the previously discussed data streams, feeds and strings are often organised in datasets. Datasets, most likely, are assemblages and are organised using some common denominator. As the following examples illustrate, the sets can be discussed in their relational context to things they are representations of, or in relation to a purely technical context, or to some other undefined data sets. Example U31, uttered in a licensing discussion group, represent a case in which the dataset is marked in relation to some phenomenon, be it sea data or city infrastructure.

U31: What are the things we are actually talking about licensing? What is kind of data that we looked at that we need to license at this point? Because we have a whole lot of different ***datasets*** *out there, right?! Starting from the* ***smart grid****,* ***movements of the sea,*** *...to* ***infrastructure..****.*

Example U32, on other hand, talks about how data is organised in libraries by data-holding organisations that release data, and manage and organise them into relational sets.

U32: Most organisations I know do it a 'light way' they issue a ***library*** *that says – send us back what you spit out, when you use this, if you* ***use the library*** *correctly, you release a* ***certain dataset.*** *(at2) /-/ you download the dataset, you run your things, and then you return to them the* ***dataset*** *and it has to look like the one you sent, (correcting herself) that one you received.*

While primarily the concern here is the technical context in which data is organised, other related features are made apparent, for example the institutions or entities holding the datasets, as well as their perceived order of things, such as internal organisational logic and possibly a more informal idea of good practice governing their policies. These most likely will differ depending on the nature of a particular organisation or company holding the data, and their strategies will affect how datasets are created, organised, used, released, archived, managed, etc. So, while there is a purely technical context for how the dataset is shared, for example, and what the relations are between the original dataset and its copies, there is also relationality with other fields of human activity, be it culture, politics or law.

This leads to my argument that data has become a 'thick concept', not only because it encompasses a number of 'thin concepts', such as the technical, for example, but due to its relational nature and the impact it has on fields in the human domain. Thus, to understand the emerging IoT paradigm means not only to uncover the cultural specifics of the time but also the significance of data and its webs of relations. Furthermore, it should be recognised that the presence of data also affects inter-human relations. Most notably this became apparent in discussions that made mention of the term 'data subject'. For example, in utterance U33, the speaker struggles to articulate when he becomes a data subject in an IoT context.

U33: I don't know. Because ***data subject*** *implies that if I am walking through my park, but there is a sensor in a park is just collecting air quality. I am not a* ***data subject*** *of that dataset but I am …*

As can be seen, in the first part of the utterance, the speaker suggests that a 'data subject' would be anyone who walks through the environment that is observed by the sensors. However, as he points out in the second part, if the sensor is measuring the air quality, he is not really a subject. This example highlights the prime complexity of the IoT paradigm. If, for example, the sensor is a CCTV camera, the speaker would be a data subject. However, in the case of air quality, where a sensor is observing some other phenomenon, does the subject presence make one a data subject? In such a context, the 'data subject' would be the air and its quality.

The discussion on the meaning of 'data subject' was mostly conducted at a licensing discussion group and at the final discussion at which participants collectively drafted what then became the final statement of the Open IoT Assembly, signed by all those present. Thus, in this context, 'data subjects' were addressed in a framework of what were called 'stakeholders'. This process of defining one or another category was not an easy task. Over the course of the discussions there were numerous occurrences when participants tried to reiterate the meaning of this nomenclature. In the following conversation, the complex relationship between the terms and their perceived meaning becomes more apparent.

U34:
S1: *Users, basically can chose the licence.*
S2: *but the question is who is the User?*
S3: *well, the owner of....**generator of data***
S4: *with smart meters it's not so. They are* ***data subjects*** *(L1)*
S2: *but then you have a question of sensing in public sphere do you need explicit consent from every* ***data subject****?*
S1: *I think they are talking copyright not licensing.*

This conversation followed the discussion on the suggested wording for the statement on the Open IoT license. At this stage of the discussion, the statement read: 'users may explicitly grant legal permission for use and sharing of the data in the public domain'. As we can observe from example U34, as speakers took turns to clarify the idea behind the statement, the difficulty about the naming surfaced. While

Speaker 1 uses the term 'user' without much consideration, Speaker 2 tries to clarify the meaning of it. Speaker 3 corrects Speaker 1 and expands the description of the user to somebody who both owns the data and generates the data. In principle, Speaker 3 and Speaker 1 are in agreement as for both of them the subject of the conversation is a person who is uploading data to a data platform.

However, the different interpretations become apparent when Speaker 4 seems to disagree with Speaker 3’s formulation by the markers 'it is not so' and a suggestion that in the context of 'smart meters' 'they are data subjects'. Speaker 2, who initially raised the question, in the next turn seems to agree with Speaker 4's proposed context. On the third turn, the misunderstanding is corrected by Speaker 1, suggesting that two different contexts of a subject have been mixed up, thus creating confusion. The key to this confusion was Speakers 3's use of the words 'owner' and 'generator of data', which Speaker 4 assigned as qualities of 'data subjects' or, in other words, individuals about whom the data is gathered through numerous sensing devices, and who, most likely, are not directly involved in direct data publishing on any data platform. In contrast, Speaker 1 and Speaker 3 assigned the term 'owner' and 'generator of data' to an active data platform user, who most likely makes the licensing decision themselves. As Speaker 1 suggested in the final turn, the nature of 'data subject' most likely would be related to a question of rights marked by 'copyrights', rather than the licensing this group tried to come up with.

After two days of intense debate, during the final document drafting session, the naming seemed to become more defined as agreements were finally reached. 'Data subjects', while still largely undefined and mostly mentioned in relation to their rights, for example, was assigned a category under the heading *Goal: Preservation of privacy*. During the discussion of this point, the first suggestion for the wording was made thus:

> *U35: 'at minimum, **data subjects** should have a right to opt out of their data being published'.*

However, 'data subjects' were not the only category of stakeholders that proved to be hard to articulate. Across this study data corpus, I identified 12 unique categories of stakeholders referred to during the two-day event. These could be categorised in a relational triangle that data moves through - the source of data, represented by naming markers such as *makers of data, data owners* and *data creators, data users, data subjects or data providers;* data hosts and managers included: *data publishers, data controllers, data licensors, data wranglers, data organisers*; and finally the data receivers were identified as d*ata consumers*.

While such triangulation helps us to think about the spatial configuration of the data and the human actors engaged in this process, it does not represent well the complexity of the interrelations of these actants. This entanglement was well represented by the following discussion. In one of the introductory parts of the discussion on access and time, one participant insisted that he did not recognise the 'we', used in the Bill Of Rights proposal and he posed the following question:

> *U36: **S1**: 'who are we in this room? Who are the **publishers**?'*

In response another participant made a suggestion:

> *U37: **S2**: maybe we should look at this in a binary sense. I'll be **data publisher** or I will be **data consumer.***

Someone else argued that within the current discourse of the IoT no one really could take just one single position:

> *U38: **S3:** I don’t know, I think all this area is a multi... thing, anyways. We had this discussion in a City group this morning identifying 7 or 8 interested parties. And that’s even we talk about owners of the public space, publisher, **who owns the equipment and publish the data**. I don’t think any... few people are just one thing. If you are only one thing, then you are a victim.*

As this short transcript shows within this group of event participants, the task to identify their own relation to the data led to contentious discussion. Notably, the notion of data publisher was highlighted in all three utterances. This was, most likely, due to the fact that the first two speakers were closely involved with data platforms and probably identified themselves as publishers. The third speaker, referencing the previous debate, however, pointed out to the diversity in the room, with a number of different affiliations the participants having spoken of. The third speaker's utterance (U38) made an invisible line between those who were actively engaged in some sort of data-related activity and were participants of this assembly, and those who were not. The speaker appropriates the use of the noun 'victim' to foretell the signalling of the perception that if one is only involved as one thing in data relations, this most likely is as the subject or consumer, thus is in a passive, victim-like position in the world of active data.

As the conversation continued and participants introduced themselves and their relations to the data universe, Speaker 2 clarified his position by making the point that he was not only a data platform owner, and thus publisher, but also an individual: 'somebody who is actually very private', as he put it. Thus he not only confirmed the above suggestion of everyone being a 'multi-thing' in an IoT context, but also extended the invisible line drawn by the previous speaker around one's professional engagement to the sphere of the personal that would most likely be identifiable with that of 'data subject' or 'data consumer'.

The other most contested term in the context of naming the stakeholders was that of the 'user'. While broadly used across the two-day discussion, its ambiguity mostly created disarray similar to that covered in the context of 'data subject'. At the final discussion, a last attempt was made to determine what exactly such a position entailed. The issue was raised when discussing the wording of the clause related to the protection of confidentiality. In its initially proposed description, the statement read: 'device owners should protect confidentiality'. The conversion that followed not only identified the link between a user as one using a data platform but also illustrated how, when thinking about these categories, participants tried to move away from the abstraction of terms to more concrete and legally defined personas.

> *U39:*
> ***S1:*** *how do we feel about 'device owners/slash developers '?*
> ***S2:*** *what if I don't own it or developed it but I take data from it?*
> ***S1:*** *I presume that was to get around term* ***'user'.***
> ***S3:*** *or we can call it* ***'licensors and licensees',*** *so that what we were doing in licensing session. And we identified 'licensors and licensees'*

> ***S1:*** *but you still agree that these can fall into one of the two categories.*
> ***S3:*** *Yes*
> ***S1:*** *Ok*
> ***S3:*** *It has to be one of those.* ***You're either a licensor*** *i.e. you take control of licensing, or* ***you are a licensee*** *and you …*

As can be seen from this conversation, Speaker 1 in turn 3 clarifies the fact that 'users' in the environment of the OpenIoT assembly were mostly spoken of in a context of a growing number of developers of internet-connected devices and that are here marked with the naming of 'device owner' or 'developer'. This reflects the historic timing of this assembly – the early stage of the IoT development, when it was most likely an individual or small start-up that created and connected sensing devices to the network. The suggestion made by Speaker 3 to adopt more judicial terminology ratifies the meaning, thus taking it into the broader context of a future business landscape and legal frameworks. Likewise, as Speaker 3 later explained, such naming was evaluated taking into account the necessary provisions for automatisation of the overall process. The following conversation took place a few minutes later after other participants joined in and contributed other perspectives on the matter. As seen here, Speaker 2 took some time to contemplate the suggestion of Speaker 3 before proposing an argument.

> *U40:*
> ***S2:*** *what if it's not an act of licensing? If there are* ***no licensees or licensors?*** *You might not license data.*
> ***S3:*** *I think there are only two* ***use values of data.*** *Only as licensors or licensees.*
> ***S2:*** *There is not going to be any licensing.* ***Licensees or licensors*** *only apply if there has been an act of licensing.*
> ***S3:*** *We were defining an automatic license in a license section, so there will always be a broad license that will be in public domain. so...*
> ***S1:*** *So, there is a default license you think?*
> ***S3****: That's what we were trying to do.*

After further debate, agreement was made to take the subject out of the final statement altogether. The final statement on the document read: 'Reasonable efforts should be made to protect confidentiality and privacy of the data subject.' The term licensor and licensee, however, did appear in the document section titled: Licensing Provisions. It is also worth noting that in this section, the term 'data subjects' was changed to an individual with further details explained in brackets: (who may not be the Licensor). This not only illustrates the difficulty in accounting for the complex relations data imposes on human relations, but also shows how far participants of this 2-day event were willing to go in order to improve the initially proposed Open IoT Bill of Rights. As was discussed in the introduction, the original document adopted the term 'people' in defining the relationships with the data universe (see full document in Appendix XI). In the final Statement of the Open Internet of Things Assembly the subject – that of people - was changed to include both human and non-human entities:

> ***Licensors*** *may explicitly grant rights ...*
> ***Data feeds*** *should have human- and machine-readable...*
> ***Individuals*** *(who may not be the Licensors)* *must* *be granted license …*
> ***Individuals*** *(who may not be the Licensors)* *should* *have the right to …*
> ***Data subjects*** *should have the rights:*
> ***Data controllers*** *should inform data subjects*
> ***Data subjects and stakeholders*** *should have a role in decision-making and governance.*

All the suggested subject categories were left unexplained. However, this was a working document produced after only two days of debate, and a note was made to agree to add more description for each term. Unfortunately, there is little evidence that anyone went any further to complete the job of correcting or explaining these terms after this event. Nevertheless, from a distance in time, it can be observed how influential both of these documents (the initial proposal of the Pachube Bill of Rights and the Statement released after the event) were. For example, in early 2016, the Open IoT Foundation published their own Bill of Rights, this time discussing data subjects purely in terms of consumers. The Consumer Bill of Rights for an Open Internet of Things[244] reduced the initial eight points to only five, mostly by scrapping the issues of access in different contexts, while maintaining some ideas from the original Open IoT Bill of Rights.

The complex relationships between the stakeholders are further entangled by numerous actants who have little to do with the ownership or licensing of data itself.

244http://openiotfoundation.org/bill-of-rights/

As already pointed out by one of the participants in example U38, there were eight different interest groups identified. This 3rd party involvement was also highlighted in one of the keynote speeches that urged participants to contemplate this complexity and the challenges involved:

> *U41: Just to point to these complex challenges: you need a lot of disciplines to work together in this Internet of Things space! Not just developers, not just* ***data wranglers*** *but* ***designers*** *and* ***ethnographers*** *and a****ll kinds of other people****.*

To summarise, the thickness of data concept is revealed by its deeply relational nature. Different bits of data are related to other bits of data such as metadata, data sets, etc. Data is entangled with other fields of human spheres, such as culture, economy, politics and law. And finally, but no less importantly, there is presence of data affecting inter-human relations. Furthermore, as will be discussed in the next section, the value of data is largely defined by these relations. The more entangled the data, the more valuable it is.

6.5. On Perceived Value and Ownership

This section will address the perceived notions of data value and how value creation is associated not only with the data relationality, but also with the idea of data ownership. As this study suggests, while the idea of data ownership and control over it is highly desirable, the current discourse of this matter has been shifted to that of the right to data access. However, let’s first attend to the notion of value. The analysis of transcripts revealed a number of perceptions of what constitutes the value of data in the IoT context.

First, the value is perceived in terms of benefit. As already noted in example U13, the speaker evoked the notion of data value in its relational setting. By combining the transport data with geo data, you can get to the bus stop. As noted, in this example the two statistical data sets combined suggest a benefit for the human realm. The same idea of combined data and that of 'more data is better' can be observed in another example utterance. Example U42 discusses the desire for combining data from multiple sources, created both by human and non-human entities. The utterance is taken from another keynote speaker whose presentation argued that the key reason for the IoT should be thought of in terms of future sustainability, used to confront environmental destruction and climate change. The example here does not name the perceived benefits, but the overall framework of the presentation acts here as an outside frame suggesting that combining 'more' or 'all' data would allow some better understanding and the possibility of more sustainable management.

> *U42: So, we going to get all the* ***consumption and activity data*** *captured and that is going to come in pretty much from anywhere, come from existing enterprise resource planning systems... it can come from smart meters... we build a system to take in data from any smart device.*

In the first part of the utterance, the speaker employs the use of data types suggesting the dialectical relation between the 'consumption and activity' and the not named data of 'all available resources', thus signalling the outside frame for the desired data interoperability and the benefits that it could bring to matters of sustainability once the match between the two is resolved. In the second part of the utterance, the speaker gives emphasis to the data, marked with the pronoun 'it', that is generated by physical things such as 'smart meters' and 'smart devices', thus clarifying the sources for types of data named here as 'consumption and activity'. Thus again, while the data is generated by the non-human entity, i.e. the energy meter, it is thought of and argued for in terms of a benefit for 'all humanity'.

Second, the value of data is perceived in terms of social capital. As the next example will illustrate, the third perceived value of data is that of capital expressed in terms of money and gain, as, in this example, it is juxtaposed with that of social capital. This was articulated by one speaker at the Unconference discussion on data ownership issues. In describing his understanding of current issues in data ownership models, the speaker identified overlapping motivations for why people share their data. Those, in his words, were altruism, socialism and egoism. Continuing, the speaker not only suggested that in the new IoT paradigm ownership might be a multi-person thing, but that our relationship with data varies from one context to another. For example, as in the following utterance, 'my data' has a perceived value that is put in the context of transaction and gain.

> *U43: I think with Facebook you want to be socialist and share the data with your friends to build up the relationship. And if someone from utility wants* ***my data*** *I want my money back as it is actually* ***my data****.*

It is worth noting that in this example, the speaker evokes both the more abstract modality of data, when speaking about sharing data with friends on Facebook, and the concrete one of 'my data', when speaking about data collected by the utility companies, signalling the already noted emotional attachment and the perceived notion of data ownership in the case of 'my data'. By evoking such opposition, the perceived variance of contexts is made apparent. Such a use of abstract modality to signal opposing contexts was often observed as the question of data value was raised on numerous occasions. In this case, the first part of the utterance makes reference to data shared with friends, and the value of data is marked by 'want to be a socialist' or, in other words, in terms of social capital. In the second part of the utterance, the value of 'my data' in the context of utility companies is perceived in terms of a monetary value.

Furthermore, as already noted with example U10[245], the value of data, in particular in terms of the common benefits, is seen when a frame of collective action is evoked or, as in example U10, other people are allowed access to 'your data'. Likewise, in examples U12[246], it was observed how the speaker pointed to the notion of a data value in the context of city ecosystems. As he suggested, the value is generated by many bodies or data belonging to citizens. To those who occupy city space, those bodies or citizens are intrinsic both to its creation and value generation. Although it was not clear what an exact measure or gain value was, the example clearly signalled that data implied some sort of intrinsic value associated with its creation or use, be it to its creators, users or data consumers.

245 “The best thing done for **your data** will be done by someone else.”

246“I don't think we need to talk about data. The **types of data** may be... the more important question is about the origins, and if the group that creates it - has some moral rights?! With, maybe... initial component ...creates finances. In **citizen data**, there is lots of booty finance, which could be environmental studies, or it could be **traffic data**.”

Similarly, when speakers evoked the collective frame, whether when speaking about the data created by many or its value for many, the emotion and care factor discussed in relation to 'my data' was present. This was most conspicuous when speakers adopted the use of the possessive pronoun 'our data' to make their points. The following example is taken from the discussion group on privacy issues, and how privacy should be articulated in an Open IoT context. Here, the speaker clearly stated her position regarding personal privacy and used the possessive pronoun 'our' to emphasise the perceived common value of the IoT data.

> *U44: I have a problem with this, not in terms of the bourgeois, in terms of class, but* ***personal data****, I mean, for me what actually matters in Internet of Things is not just your data, but* ***our data****.* ***Social data*** *is meaningful. It's not about individual only data, it's about the data we all create together and share. So it is this collective intelligence that I care about. Because only by understanding that, it is not just a social graph, I mean, it's bigger.*

As can be observed, the speaker here addresses the context of collective data, or what she calls 'social data', and its value is seen as benefiting all. Another representative example of this could be found in a discussion in a group concerned with the Open IoT in the context of city infrastructures. In this example, the speaker replaced the possessive pronoun 'our data', used in speech beforehand, with that of 'citizens'. Here, not only does the speaker suggest that data belongs to many individuals or is collective, but also suggests that the value of data is created by those generating it. In this instance it is unclear if speaker means monetary or social value; however, taking in account her overall argument we could make an assumption that data generated by citizens have a social or common value.

> *U45: It is here again when citizens are generating the* ***value for data.***

The idea that IoT frameworks offer a significant shift from concerns about the personal sphere to those of shared public resources and common values has now been articulated by many thinkers (Rifkin, 2014, Bauwens et al., 2017). Within the context of the Open IoT Assembly, likewise, there were numerous discussions provoking common concerns about this shift, be it to shared city space or on a planetary scale. As my data show, the word 'public' was the fifth most used concept across the two-day event, while the word 'commons' took tenth place. The data value in this context was not only emotionally argued for but also articulated in different ways: 'data created by us', 'social data', 'shared data', 'commons data', 'collective data', 'citizens data', 'everybody's data'. In such a context, the value or benefit of shared data was mostly articulated in terms of 'collective intelligence', as seen in the above example U45, or a broader framework of knowledge acquisition. In a discussion about the purpose of the Open IoT on a planetary scale, for example, one speaker tried to articulate this in the following utterance:

> *U46: I mean what we see is that IoT is a social made out of knowledge, it is integrated into materiality, so, I wouldn't even like to make that distinction. Because, I mean without the knowledge, **social data** that we share, the understanding and interpretation, it does not really make sense.*

The value of data is closely linked to the perceived notion of data ownership. This can be observed on numerous occasions, such as in example U46 above in a collective context, where there is a perception that 'social data' is something we share and somehow we own it as a society, or in the context of 'my data', in which the idea of ownership is repeated insistently, as in example U43 or U9[247]. Here is another example (U47) highlighting this issue. The speaker employs the use of abstract modality and evokes the notion of data as a trading token while making an argument about data ownership. The utterance is made in response to the previous conversation in which the suggestion was made that there could be two types of data in relation to one’s body - organic, something you have been born with, and synthetic, data collected by some sort of sensor - thus prompting differing terms of ownership. The speaker argued that he would still expect to own the rights to data produced by sensors if acquired in a commercial transaction.

> *U47: You give me a free service; I give you data. But in this one, I make a purchase of the product and I might still expect at that point **I own the data rights** that product produces 100%. So that's a commercial transaction. And in this case, I would expect to **own data** even though the source of that data is inorganic.*

247“There needs to come some kind of anonymization mashing that is non-corruptible in a process. And once we got that then we are in a chain. But if you don't have any of that, then frankly I don't have any of my personal data up there.”

As highlighted already by example U25[248], negating the ownership issue was not an easy task. There are a number of variants in what constitutes data, its location and its relations to a number of other factors. Example U47 also highlights often observed situations in which the notion of 'ownership of data' is frequently muddled with that of 'ownership of data rights'. Nevertheless, in all the cases when speakers evoke the notion of 'my data' or talk about data value there is a perception that ownership is or should be possible. This suggests that in one way or another one should be able to exercise some control over the data or its use. Yet, most speakers are well aware that data only exist in some data warehouse they have no control over.

The perception of ownership, and thus control, of one's data is often highlighted by the use of the active voice. Conversely, when speaking about engagements with data that are collected by somebody else or their value is understood in other related contexts, speakers in the study used the passive voice. In these situations, they most commonly used no subject intransitive verbs, as in the following example:

> *U48: When I go to the doctor, **data is aggregated** for the doctor, **it's my health record***

While the speaker in this example clearly is concerned with data that includes his health records, the passive voice is used to negate the reality in which he has no influence. The same situation can be observed in the next example (U49). The use of the passive voice has been evoked in different contexts, when speaking about some institutional settings or the doctor's office, as in the example above. The following example is taken from a discussion about the IoT in the context of home, where the activity of data logging is done by a third party; thus, it is perceived as a space where influence is lost.

> *U49: Say for instance ….. data ….home …... and they are **on behalf** of ...amm but it is **logging data** about you.*

The speaker here is not confident as to how to formulate the complex relationship of the actants involved in the data transaction. In the first instance, he attempts to

248“So the creation process implies the ownership. Then there is the next one that you get somebody to create data about somebody else, data describes another person …then the person owning... that data somehow....who is owning it in the end....every data we create is about something or somebody else...”

construct a sentence with 'they are on behalf'. There could be two readings of what 'they' here signify. One reading could be that 'they' are the company providing home sensing equipment 'on behalf of' me, i.e. a customer; alternatively, 'they' can be the devices that act 'on behalf of' the company. As the speaker corrects this utterance by assigning the 3rd person pronoun 'it' to the subject, it is most likely he means that 'it' is some sort of sensor recording/monitoring device in a home setting that is 'logging' data 'on behalf of' a company. Nevertheless, in both examples, the speakers struggle with what could be identified as cognitive dissonance, as what is perceived to belong to a speaker, be it 'my health record' or 'data about you', may well belong to somebody else.

Thus, the already noted confusion between 'ownership of data' and 'rights to data' appears to be a way of speakers negotiating this dissonance created by the perception of data ownership. The notion of 'rights' implies some kind of access to data, and its legal framework offers a region where at least some control over data could be exercised. During the Open IoT Assembly, there were tense discussions in a group which was focusing on ways to negotiate the matters of data access and time. A number of speakers spoke passionately about the need for some type of control mechanism that would allow data users or data subjects to determine for how long and over what period of time data should be kept, or at what point data should be deleted. For example, one participant highlighted her possible desire for wanting to delete her data.

> *U50: I might not have this option, ….might be forever...so I have to define as a user – I want* ***my data*** *to be deleted after a certain amount of time.*

In the first part of the utterance, the speaker hypothesises, by use of the modular auxiliary 'might', suggesting a possibility that could occur followed by the desired action that should be taken in order to ensure that the human actor has a say on the timelessness of data. Then, the already discussed use of the possessive pronoun in context to ‘data’ signals her perception of data ownership and the need for the desired care. The use of hypothetical modality here signals the uncertainty of the context where one's data will be located. With the use of an assertive form of ‘I want’, the speaker clearly signals the desire for being in control of her data.

However, as can be seen in the final statement released after the Open IoT Assembly, what seems a reasonable human desire to control one's presence in a space encapsulated by the IoT domain is a folly in the context of the technological framework installed. In that final document, all 'my data'-related concerns, such as expressed in the example above and others, were placed in a stakeholder category of 'data subjects', and positioned in relation to another stakeholder category, that of 'data controllers'. After long discussions on the desired rights to determine when and if one's data could be deleted, the assembly came to the conclusion that the only rights of the subjects in this matter were to be informed about the impossibility of deletion once data was published. The final statement on this matter read:

> *U51: **Data controllers** should inform **data subjects** that deleting all copies of data may be technically unfeasible once published.*

As noted, there is overwhelming evidence that we perceive data as something that has a value. The value may be in terms of benefits, social capital or in monetary cost. Furthermore, the value of the data increases with their interoperability. Data is valuable both for individuals and for all of us as a collective, which has led to calls to consider the concept of data commons[249]. This, as the previous section of the study highlighted, is particularly relevant in the context of citizen science, citizen sensor networks and the general IoT framework, in which data is collected in both private and public environments. It is not necessarily the case that more data means better data, even if such rhetoric was observed in 2012; it is that its value lies in webs of

249'Data commons' is a concept traditionally used to describe the data that is in a public domain or data created by scientific research. In a context of social research data, Yakowitz has defined data commons in the following way: “The data commons are comprised of the disparate and diffuse collections of data made broadly available to researchers with only minimal barriers to entry” (Yakowitz, 2011:3). See also Halpin et al. (2006) for a proposal for data commons for biogeographic and conservation research. More recently, the concept also envelopes citizen science data (see for example Cuff et al., 2008). Increasing computerisation, however, is shifting the data commons discourse. In 2008, the Open Knowledge foundation (UK) initiated work on the Open Data Commons (see Miller et al., 2008) and now defines it as the framework that “provides a set of open data licences that enable organisations and individuals to make their data legally open — free for anyone to use, reuse, and redistribute” (see full description at: okfn.org/about/our-impact/legaltools/). The Open IoT Assembly was seen as the next step to broadening this framework, and the licensing approach was to include the IoT domain data-specific issues. The developments in this field are ongoing. In 2016, the New Zealand Data Futures Partnership, the NEXT Foundation, the Bioheritage Science Challenge, and Infection agreed to co- fund the development of a blueprint for an alternative model to enable data sharing in New Zealand. (see: //datacommons.org.nz). The same year, the UK joined a European framework project to consider what a 'new family of data commons' would look like (see www.nesta.org.uk/blog/a-new-family-of-data-commons/).

connections. If we take as an example the AQE network data, its value would increase if an attempt to interlink it with more established environmental data sets were to be made.

With such recognition, the question of ownership comes to the foreground. In this study of perceptions, I observed that many in the Open IoT Assembly believed in a person's right to own data that had been created by their bodies, or data created about them. As I argued, in cases when data is perceived to have a value for an individual, be it data of one's body or about one's persona, people express the desire to have some control of that data. The lack of control signals the emergence of a kind of cognitive dissonance, a gap between one's belief in being in control of one's data and the reality, which is that one has no control over it. To reduce the cognitive dissonance between the perceptions and a reality where the prospect of ownership of data itself seems unattainable, strategies have been adopted to shift the issue of ownership to a concept of rights to access.

6.6. Data Space

This section will address the spatial perceptions of what I will call here a data space. I will use this concept to describe speaker perceptions rather than refer to them in terms of databases, a traditional notion of where data is kept, nor in terms of digital storage or abstractions used in the data management field that aim to overcome some of the problems encountered in data integration systems. The focus here is on how speakers articulate not only the location of data but also the data spatial configurations in the IoT domain.

The perception of one's control over data, or lack of it, is also reflected in the perceived configuration of the space the data occupies. My analysis of metaphor used in relation to what is and can be done with data revealed a significant number of spatial metaphors. This might relate to the network structure of Internet space as, since the invention of the Internet, scholars have often pointed out that network navigation is considered in terms of a cognitive map similar to that of physical space (Vaananen, 1994; Maglio and Matlock, 1998; Jamet, 2010). Examples of this can be found across different speakers' utterances. The most commonly observed one was a simple statement such as the abstract use of space in example U52, which points to data somewhere 'out there':

> *U52: So,* ***your data*** *is* ***out there***

In this utterance, the speaker uses the second person possessive pronoun, which, as noted already, evokes an emotional attachment, and with it the perceived value of that data, that is now 'out there', i.e. away from you. Similarly, in another example, taken from the discussions about data privacy, the speaker used the verb 'to put' data 'out there', thus again signalling some spatial configuration that is far away from what could be presumed to be 'here', near the speaker or data producer. However, example U53 gives us some insight into the speaker's perception of that space 'out there':

> *U53: If we were to put* ***our data out there*** *and whoever can do whatever with it.*

In the first part of the sentence the speaker again appropriates the use of the possessive pronouns 'we' and 'our data', thus signalling emotion and perceived value, and employs the verb 'put', suggesting that 'data' would be something tangible that we can put away. Likewise, 'put out there', signals the movement from one space to other or away from a space one occupies. In other words, the trajectory metaphor discussed previously. In the second part of the sentence, by the use of the modal auxiliary 'can', space is created that is perceived as one dominated by uncertainty and lack of control, as marked by the use of two pronouns 'whoever' and 'whatever'.

While both the above examples create an abstract vision of that space 'out there', example U9, discussed previously, offered the more concrete perception of the space speakers refer to, that of a data platform. In example U9[250], the speaker made the suggestion that there should be something 'between' the user and the data platform that could anonymise data before it is deposited in the data depository. Here, the

250U9: 'that's a really good idea that there is something **between** the user and **the whatever data platform** their data goes into but how can that be done? But if you don't have any of that, then frankly I don't have any of my personal data **up there**.' (gesture: moves the hand upwards).

space is created rather vividly. There is not only space 'here', where the user is, and 'there', where the platform is, but also there is a space in between that needs to be addressed. By employing the verb 'goes' in relation to data movement, which is unidirectional, and the spatial preposition 'into', which, we could argue, mimics the previously discussed metaphor of plugging, there is a perception of a data platforms being a sort of container. Likewise, during the utterance, the speaker makes a hand gesture upwards, one that implies the perception that data is up there, somewhere, a perception most likely identified with the cloud metaphor used in the concept of cloud computing, something often associated with data platforms.

The 'put' metaphor is frequently used in the IoT data context as data needs to be somewhere in a space of the Internet to be useful, to be observable, etc. It can be expressed in more abstract spatial terms, as in previously observed examples, e.g. put 'up' on a cloud, up there, or it can be 'put in' more concrete places, like repositories, archives, collections, or data centres, as in the following example:

> *U54: **Everybody puts** their data **in data centres** and **data centre** owns the intelligence*

Besides highlighting the spatial context of data, which in this sentence is located between the space marked with the third person possessive pronoun, which creates some distance and indicates less emotional involvement, and the space/place of the abstract data centre, the speaker here also evokes oppositional frames in which the perceived value of data that should belong to 'everybody' is displaced into the 'data centre' that 'owns the intelligence'. This not only suggests that there is a loss of control over the space where the data is, and thus the data itself, but also that the value that is perceived as social capital is in an ownership of space 'out there', thus the perceived value of the data benefits not 'everybody', but the few.

To summarise, data is a subject and object that is not only located in perceived spatial configurations but also through it, space is created. These spatial configurations further extend the questions of value creation and ownership, as well as the meanings we assign to each of these contexts. Furthermore, the spatial configurations of data, as in the physical world, engage with a discourse of private versus public, social versus business and collaborative versus market domains. While the space out there is sometimes perceived as shared and thus public, in reality that space out there is most likely owned by some private, corporate entity. Thus like a spatial practice, explored in the previous chapter, data itself exists in a constant flux of these multiple realms.

6.7. Conclusion

This chapter, through the analyses of concept word use in speaker utterances, aimed to uncover the key ideas that lie at the core of the IoT discourse. On the occasion of the first Open IoT Assembly, the research data was gathered across this two-day event, which included a number of presentations, themed and parallel Unconference discussions, and a final discussion during which the Statement of the Open IoT Assembly was collectively negotiated. The statistical analysis of the data corpus (totalling 69,024 words) uncovered that the most uttered word during this two-day gathering was that of data. By untangling the term's use in language, the study aimed to uncover the culturally specific significance of data in the perceptions of the early IoT adopters. By borrowing Geertz' terminology, the thickness of the data concept in the context of the IoT domain soon became apparent.

The study identified three main contexts that speakers evoke when talking about data. Those were technological, human and more than human contexts. It was observed that the meaning of the data concept in a discourse of IoT is changing. While many of the naming strategies applied in its previously static contexts are still at work in the context of the IoT, its previously perceived static qualities are almost absent. Data in the IoT context is perceived as fast moving, active, relational and massive. Furthermore, it was observed how speakers in this community also apply the data-related concepts from its technological context to the human realm when explaining or dramatising the meaning of some event outside the technological framework.

The study of data concepts used in a human context revealed that an analysis of the use of the possessive pronoun can help to uncover indicators for affiliated emotion.

This was most present when speakers evoked the notion of 'my data' that expressed strong emotional attachment and desired care for that data. It is evident that emotional attachment is also evoked when speakers adopt the second and third person possessive pronouns, though this attachment can vary in intensity. Similarly, the use of plural pronouns, as exemplified in the case of 'our data', is argued for in highly emotional terms. In addition, I argued that affiliated emotions correlate with a perceived value of data and its ownership.

When the concept of data is discussed in a context of non-human or more than human entities, the first thing that stood out in this study was the normalised notion that all 'things' have the capacity to transmit data. Second, for this study's subjects, the data generated by non-human entities was perceived as impacting the human context rather than the context of the things themselves, be it in terms of value or its relationality to a context. Furthermore, the presence of more than human entities suggests a shift of focus from concern about the meaning of things themselves, or what things mean to us, to that of an effect; or in other words, what the effect of one thing or another on ourselves is, on our bodies, our minds, our perceptions and the world. Such entanglement suggests that data, in this context, is most likely subjected to concerns of human context.

The analysis of metaphors revealed that for the early IoT adopters, at least, data had a man-made quality. This could be observed by the use of metaphors borrowed from the crafts domain. In addition, many spatial metaphors were observed. Most vividly, the trajectory metaphors, for example, signal a distinct perception that data has a source and the most observed metaphor concerned a movement outwards, away from the agent or data originator. Furthermore, the perceptions of data are shaped by a conceptual aboutness. This suggests the perception of data is something that is by default relational in its nature. This relational nature of data was further explored. The study revealed data is relational within itself but is also in a relationship with other fields of human spheres of action, such as culture, economy, politics and law. Likewise, the presence of data affects inter-human relations. Furthermore, the value of data is largely defined by these relations; the more entangled the data is, the more valuable it is.

The value of data, as it was observed, is most commonly perceived in terms of benefits, social capital or financial gain. Furthermore, in the IoT context, data is also perceived within a framework of common action, as something created by many, and its value thus offers common benefits, or in other words data has a common value. The perception of value is closely related to the perceived notion of data ownership. Through expressed emotional attachment or requests for care of data, speakers conveyed their desires to be in control of data which they perceived to be theirs. The lack of control signals the emergence of a kind of cognitive dissonance, a gap between one's beliefs in being in control of one's data and the reality, in which one has no control over that data. The dissonance was also observed in the speakers' perception of spatial configurations data inhibits as data that is perceived to be close to one's body, in reality, is produced, assembled and stored in a space outside of the individual's sphere of influence. To reduce the cognitive dissonance between the perceptions and a reality where the prospect of ownership of data seems unattainable, strategies are adopted that shift the issue of ownership to a concept of rights to access.

This study represents a small sample case of people who were concerned with the emerging IoT paradigm, and their perceptions of data at that certain historical moment. Their language and perceptions might be associated with that of a single small sample of a professional class. But is this phenomenon unique only to them? And why would they be concerned about these issues? As one of the observed participants argued, besides being professionally involved in this discourse he was also a person, and a very private one. As data diffuses in both the private and public realms, its influence on our lives will increase. It has penetrated deeply into our understanding of what we perceive to be a human realm, or in Arendt's terms, the social world; thus, it can be hardly seen as neutral. What does it mean when a thick concept such as data penetrates the social fabric of our world? Does data in the IoT context become the digital flesh of the things that bind us with our bodies? If it is the extended flesh, should we own it, or at least have rights to it? If we do not have control over it, will the magnitude of dissonance increase or decrease with time? Or will its effect make us adapt? As critical data theorists have recently pointed out, the effect data has on the human sphere shifts not only the discourse but also the socio-material reality and political concerns (Gitelman and Jackson, 2013; Ribes and

Jackson, 2013; Crawford et al., 2014). As my study has shown and later research has confirmed, people are not at ease with this emerging world. Nafus and Sherman (2014), in their study on the Quantified Self community, pointed out that even when data is being generated, individuals are not necessarily willing participants in the big data project. In a context of social media, Hintz (2015:157) argued that the digitisation of social life transforms the 'social into searchable, mineable and profitable databases', suggesting possible reasons for the unease felt by data subjects. This not only reflects the findings of this study but also confirms that the shifts brought about by the IoT will be, and I argue here in agreement with Kitchen (2014), rooted in data-intensive exploration.

7

DISCUSSION

The first part of this thesis explored the historical discourse of IoT which, as it was argued, was firmly rooted in the realm of technological development, and conducted mostly within frameworks of large academic and commercial technology research centres. The developments of the IoT were rather slow and, around the time of this study, the research was still quite scattered and primarily articulated Ashton's vision of the thing identification, management, automation, and data gathering in corporate frameworks predominantly. In other words, if we employ Lefebvre's tools of space triangulation, the dominant space of IoT was mainly occupied by the 'anywhere, anytime, anything', while its technological applications were governed by the implementation of tagging and tracing technologies, primarily through the use of RFID.

The case study in the second part of this thesis focused on one group of early IoT adopters who, at the edges of these established networks, galvanised a community of contributors to create the precedent for a collaborative development of an open source IoT device and a framework for open IoT discourse. This analysis of practices at the edges of dominant space not only argues for the relevance of these practices, but also uncovers the visions and approaches of these developers. Furthermore, as suggested, this was an instrumental study that aimed to facilitate our understanding of the emerging IoT phenomenon. The following discussion will address the key findings, both in terms of intrinsic and instrumental scholarship.

First, we address what we have learned about the IoT through the analysis of perceptions and practice of the Pachube community members. As was observed, participants' visions of the IoT, while resonating some of the larger IoT discourse themes such as 'anywhere, anytime', insisted on far more social relevance of the IoT or what one participant called a 'revolutionary development'. They advocated for a human-centric IoT in describing the future vision of an interactive or responsive environment that is attuned and adaptive to the needs of a human being, a liberating place that helps us to get away from our screens, or an environment that gets out of the way and permits us do things we care about. Thus, in contrast to the visions of the dominant discourse with its focus on tracking and tracing, this is another vision - of an interactive, responsive environment that is shaped by human needs and actions.

Such a vision of IoT, I argue, is not only contrary to a dominant discourse, but also mirrors the ideas rooted in earlier avant-garde traditions of the 1960s. As was highlighted in the introduction of this thesis, Usman Haque, the chief architect of the Pachube platform, often made references to the work of the Dutch artist and situationist Constant Nieuwenhuys and his proposal for the New Babylon (1956 -1974). The New Babylon[251] envisioned a 'worldwide city for the future' where land is owned collectively, work is fully automated and the need to work replaced with a nomadic life of creative play" (Zegher, 1999:3). Reiterating this 1960s vision of an environment that could be created by the activity of life, configured and reconfigured by its inhabitants, in the context of the IoT, is haunting. On the one hand (and believed by these IoT advocates) the technological development of such environment is nearing. It is, however, less clear how the social relations, suggested by the New Babylon, will take form in a framework of future IoT. In their own practice, however, they did made an attempt, even if faintly, to test and implement some principles of collective ownership in their design approaches. Thus it could be argued that not only their aspirations, but also their chosen methods and approaches have roots in these past traditions in fields of art and social cultural production.

Before turning to the analysis of their practice and how their visions materialised, there are a few other perceptual features of IoT worth highlighting.

251 The title of The New Babylon was borrowed from the 1929 Russian film that was set in times of Paris Commune (1871), footage also was included in Guy Debord's film *The Society of the Spectacle* (1973).

It was observed that while the role played by the device in spatial reconfiguration became more prominent, the perception of the underlying network was diminishing. The place in cyberspace was called upon in a similar manner to a place in a physical world, as in the example of ‘Pachube being the only place to go'. On the other hand, the collective practice of this community was centred on the development of IoT device. This practical engagement may be a reason why their visions of IoT were often articulated in terms of devices and their relationship to things they were measuring (see Example 6). However, our analysis of perceptions regarding the devices in part one of this study revealed some interesting findings.

When speakers engaged with the subject of IoT devices, a separation between future and current timeframes was often made. For some, devices are extensions of the body while for others they are extensions of the outside world. In the future, devices were perceived as autonomous, involved not only with sensing and measuring, but also somehow empowered to communicate with us and among themselves. This reflects the debates, highlighted in the theoretical part, as contentions often emerge around the question of what degree of agency a device in IoT has. In the perceptions of these developers, in the future a device should have ability similarly to 'know' and to 'act', however, the agency of a device was perceived to be more relational –for example[it] '*gives us ability... the agency to interact'*. In other words, it is the device's ability to enable and support a human agency.

Moreover, this perception of a device's ability to empower human agency was not only expressed in the context of a future vision in which a number of possible algorithmic or AI layers might make such knowing/acting possible. It was also present when speakers referred to current developments, the phase of the development that emphasised 'playing with', 'hacking sensors', and 'making sense of data', however 'accurate it might be' and validating it by any means available. There is, nevertheless, a difference. When 'knowing' is mentioned in a context of the future, it referred to a technological framework, while 'knowing' in the present relates to the phenomena or the aboutness of the thing that was measured by the device. Yet, as noted in the discussion of Example 3 (see page

109), the notion of a device in the present is already perceived as a container of a certain objectivity, or, in other words, is seen as an empowerment tool to overcome the limitations of subjective knowing, thus suggesting support of a non-human actor for the human agency to act. On the one hand this suggests that what Kera and Greham (2010) called a 'new sense of community' embraced by collective sensing networks creates a symbiotic relationship that may lead to a refusal to accept any responsibility. On the other hand, as highlighted by the AQE legacy projects, when such devices are put in practice they do already empower humans in their social struggles, simply by offering non-subjective data readings.

The next thing we should address is the vision of *the thing* out there, the IoT is set to bringing us 'closer to', in this case the air-quality. While the dominant discourse of IoT focusses on tracking and tagging goods and services, this community was more concerned with collective understanding of the environment, air, water, and pollution, and collective ways to manage their impact and effects. This engagement with environmental issues, I argue, shifted the community's focus from that of a purely technical interest group to the larger framework of citizen science. However, as my observations revealed, the developers were less interested in quality of data and, as we saw, the data delivered by the AQE V.1. was unreliable. This would suggest that they were less concerned with the air-quality as such, or its impact. Rather, their concern lay in the process of development and the creation of open tools that - as expressed in their AQE project slogan – facilitate 'a way to participate in the conversation about air quality' (see page 170). However, by employing the tactics of public debate they raised awareness of issues related to air quality, but most importantly, I would argue, they opened up the debate on the complexities involved in a measurement process, calibration, and meanings created by the real-time IoT data. In other words, their practice highlighted not only concerns about air quality, but the importance of processes that lay at the core of the IoT implementation and thus, as Hanna Arendt argued, require public scrutiny.

The AQE project was the community's opportunity to open up public discussion not only on environmental questions, but on questions related to the processes of measurement and emerging power relations in IoT context. Following this community's struggles with the measuring process revealed both the technical difficulties involved in any process of measuring as well as the socio-economic aspects of these processes. For example, the debate about the chosen sensors revealed how the appropriation of 'cheap', uncalibrated sensors undermined the understanding of what was measured. It also revealed how the cost of technology or the economic factors, in this case the use of 'cheap' sensors, can impact on social aspects such as trust. The measurement debate also highlighted the complexities involved in assemblages of several pollutants. What gets measured? What defines the choice of what is getting measured and by which means? For example, the difficulties with implementation of radiation sensors in the AQE1.0 design foregrounds the technical issues involved, but also affects the use of the device in certain contexts. Similarly, the calibration debate opened up this very process to public scrutiny. How it is done, who and what is involved, by what means, and in which context? If we are to accept the data delivered by the IoT devices as a new truth about, or as the nature/flesh of the things out there, we need to be aware of processes that take place in shaping that data.

By turning the public's attention to the issues of measurement and calibration, the AQE project disclosed the centuries-old problem at the root of the western scientific approach - abstraction and increasing approximation through mathematics and, now through computation and AI, are the methods continuously used to achieve an objective worldview. As IoT is set to further objectify the messy and untidy physical world it is a valid question to ask - how is such objective knowledge created, and how does it relate to the every day of sentient beings. This intention to raise the question was observable in statements such as: it is 'our desire to give the planet a voice' rather than just to objectify and rationalise the universe out there, which the dominant IoT discourse suggests. Thus, the AQE project can also be viewed in terms of 'asymmetric social struggle' (Graham, 1998:176) in a context of IoT development, or, as a proposition, an attempt to address the balancing of subjective and objective knowing in this new context. As this study showed, their approach was threefold. First, they opened this process for public view and scrutiny. Second, by arguing for the open source and DIY approaches they advocated methods of learning by doing, or, in other words *Praxis* (see Kranenburg, 2008:10); and third, they made an attempt to embed the human feedback trigger in the device design and data architecture to highlight the necessity for subjective feedback.

This more participatory approach, for example, would be particularly relevant in a context of the 'retuning' (Coyne, 2010) of space/place relations (see chapter 2.2.3). How and by what means is the 'retuning' guided? As this study showed, even if the data generated by a device is not calibrated, it can affect how we perceive the place we inhabit, for example. As highlighted in this community's debates, visual readings of data and changes in graphs at certain times of a day can tell a story. How do we interpret that story and act upon it? Do we sell the house and don't tell the buyer about the readings of IoT device, and the subsequent change of our perception of the place? These are complex ethical questions and design affordance such as the human input trigger may not be able to resolve it. Yet, another variable could provide the depth to that data story that, as observed, is already 'retuning' our perceptions of place. Thus, this study showed how in the framework of the emerging IoT, the perceptions of both physical world and cyberspace are undergoing enduring transformation.

This brings us to the final point this study disclosed about the larger IoT domain – that of data centrality. While the second part of the study gave us some indications of this phenomena, it was the tools of linguistic ethnography (Duranti, 2003:332) that revealed its extent. The emergence of data discourse at the centre of the IoT domain shifts the power relations between the growing numbers of actants in the IoT space. For example, attention is shifted from the device or thing to data. Likewise, in the context of IoT the notion of data is also changing. In this new context, data is perceived as fast moving, active, relational and massive. Thus, I argue that data has become a thick concept (Geertz, 1973), and as such demands thorough investigation and further studies.

As this study's findings suggested, there is a growing dissonance between the perceptions of data, its value, ownership, its public and private quality, and its reality. For example, when speakers used the possessive pronouns such as 'my data' and 'our data' there was observable indication of emotional attachment that differed from when other adjectives were used. Furthermore, the attachments expressed in the concept of 'my data' were often related to the issues of ownership. As was observed, while 'my data' indicated suggestion that 'data is owned by me' as 'my data', speakers were well aware that there are other owners of 'my data', such as data platforms, energy companies etc. This perception of ownership further impacts the perceived value of data. As the study identified, the value of data in the perceptions of speakers were closely related to the contexts of public and private realms and expressed in social or monetary terms. Likewise, when a frame of collective action was evoked the ownership of data was perceived in collective terms and value of data was articulated in terms of the common benefits.

However, while the idea of data ownership and control over it is perceived as highly desirable, the discourse on this matter, during the time of my observation has already shifted from data ownership to that of rights to data access. This was best illustrated by the negotiations surrounding the articulation of what was initially titled the Open IoT Bill of Rights. The original Bill of Rights proposed by Usman Haque and Ed Borden in 2011 emphasised people's ownership of data, expressed in the statement 'people own the data....' After two-day negotiations in June 2012, the same clause in the final 'statement' published by the Open IoT Assembly only suggested that 'people have the right to'. This is not only the indicator of simple change in language, but rather the shift in a larger contextual frame. This shift from the socialist ideals of common ownership, made explicit in projects such as Nieuwenhuys' the New Babylon, were coerced into a framework of current day neoliberal[252] form of language. Likewise, this shift would indicate some closure on the proposition Haque and Borden made in 2011, by suggesting that there are only two ways to address the data ownership – a) by controlling people's access to their data, and b) by unlocking data from the silos in which it has been restrained (see Haque and Borden, 2011).

Yet, the discussion on data, its open or closed nature, value, and ownership is ongoing (Mashhadi, et. al., 2014; Christidis, et. al., 2016; Mineraud, et. al.,

252I use here Harvey's articulation of the term (2005: 2).

2016; Blok, et. al., 2017; Wolfert, et. al., 2017; Azar, et. al, 2018). While in 2012, the Open IoT assembly set on the pass A, to achieve the vision of integrated IoT systems there is a need for interoperability. This suggests that issues of data formats and fragmentation of data in data silos is a challenge likely to proceed, as will the new approaches to address this issue (Desai, et. al. 2015; Bröring et. al. 2017). As more data is created, the research and implementation will undoubtedly face the future challenges of current restraints. It remains to be seen whether and how the emergence of 'open', 'smart', and 'human centric' frameworks will affect this discourse in the future. Data delivered by IoT devices can improve human ability to understand what was previously invisible; however, as this and other studies (Sheth, et.al. 2016) suggest there is the ever-growing need to address the perceptual issues and its integration in the IoT data context.

The IoT is an emerging phenomenon and its future hangs in the balance of how these challenges are addressed and how these visions of human-centric approaches can be implemented at scale and in a sustainable manner. This brings us to the relevance of everyday practice and why there is a need for intrinsic studies such as this that explore the methods and workings of practices that embrace human-centric visions of IoT, cooperation, and common resource development. Thus, let us briefly address the key observations and what can be learned from this analysis of Pachube community's practice. They embraced a vision and utilised it for community's cohesion, developed a strategy, and carried it out in a collaborative manner. To do so they adopted several methods and as a result created a space for a new discourse to emerge.

First, let us address the ways they created the vision and strategy for community engagement and collaborative development, and then address the methods embraced. As noted, in contrast to the dominant discourse that was concerned with the connectivity and tracing things in 'anything, anywhere, anytime' framework, the Pachube community advocated the vision of an environment that supports the human agency. They argued for practice-based learning, collaborative resource development, and open discussion on IoT future implementation. To galvanise community engagement, as I argue above, they pursued the matters of public domain by addressing common objects of concern – the air quality, and the need for citizen tools. As Axelrod already observed, 'cooperation can begin with small clusters. It can thrive with strategies that are 'nice', provocable, and somewhat forgiving' (Axelrod, 2006:3).

The key strategies to sustain the community's engagement were emphasis on openness, collaboration in public view, and a hands-on participatory approach. These approaches were particularly highlighted in the second part of the study, in describing participants' articulations of what sets this community apart from other formations that were similarly working towards the developments of air quality measuring devices at the time. The literal spelling out of these principles are observed in Example 2 (see page 155) in which the speaker described the most valuable element of the project: 'The most valuable part of it is the way it is an extremely democratic and community driven project'.

As it was noted, the speaker's response on a question 'what is meant by 'extremely democratic'?' was pointing towards a number of online and physical spaces that the speaker associated with contexts of public space. Meetup.com, Github.com, Wikis and google groups, as well as a number of arts and community media spaces where prototyping workshops were held, together created the public realm in which their ideas could be challenged, questioned, and argued for. While we could argue about the true nature of these social platforms, for the purpose of this group's communal action, they provided the conditions for plurality where, as Hanna Arendt (1958) suggested, the disclosures of 'who' can take place in a public view. Likewise, the utilisation of Media Art centres such as de Waag in Amsterdam, or Eyebeam in New York, not only confirms the public nature of these institutions, but also the community's close ties with the media art practices[253] and its position to negotiate institutional contexts (See Corby, 2005).

Much could be said about the methods and approaches employed, and how they reveal the character of this community. For example, the notion of craftsmanship, as

253 Corby in his 2005 editorial book *Network Art* practices suggested that a number of distinct positions could be identified in methods used in media art. 'One of the most compelling aspects of Network art - particularly in its early years in the form of net art - was the manner in which it aspired to reinvigorate a number of earlier avant-garde traditions. In doing so they hoped to fulfil some of the utopian strivings of earlier times by establishing a genuinely participatory and democratic mode of cultural production which collapsed art into life' (Corby, 2005:6).

Sennett argued is 'focused on achieving quality and doing good work' (Sennett, 2008:25). This relates both to a traditional craftsman, or an artist, and the contemporary programmers of open source. However, while both manage the problem solving and search for solutions that lead to elegant closure, for the latter the work is never finished as such, as the code is constantly evolving, be it into the next stage of 'bug' testing or the development of additional applications. This is best revealed by the work of Usman Haque - his *EnviromentXML,* this system's three testing stages in art works *Environment I, II, and III* and, finally this system's adaptation into the scalable Pachube platform. There could be much said about this transition in which the work of art (*EnviromentXML)* 'collapsed into 'life'' (Corby, 2005) (Pachube). In this study Pachube was primarily discussed in terms of the platform's interface designs, its role in user data visualisation and storage, and in terms of aesthetic and structural changes that occur during two years of Pachube start-up transition. There could be, however, a number of different approaches in which this transition could be discussed, as it is not often explored how an artwork is turned into viable, commercially sustainable, user-centric system application. However, it was intentional to move away from this artefact itself as it was the systems relational aspects to the community formation that we wanted to focus on. Yet, it is worth highlighting it here, as nothing in this study would have meaning without this underlying web structure.

This underlying system, as much as any other technical developments undertaken by this community, brings to the foreground collaborative aspect eminent to both art and open source practices. The collaborative aspects in art practice, such as adaptation of collective identity and skill sharing (Black and White, 2013) are also well embedded in practices of open source communities (Raymond, 1999; Yuill, 2008; Colman, 2015). The value of open and collaborative processes were often highlighted by this study's participants, both in their speech (see example 4, page 112) and actions (see chapter 5.3.1). On all levels, the Pachube story is a story of collaboration. From the Pachube system development, which was a collaboration between Usman Haque and software engineer Sam Mulube, to the development of the Air Quality Egg device and Pachube community network, every step contained some form of collaborative negotiation.

Open source methods were, without a doubt, the most referenced influence to the practice of this community. From publishing the software code and implementations of open design approaches, to community's discussions on calibration and creation of the open source product, the support for open source culture was paramount here. However, as it was also observed, for example, the process of growing their user base, one of the key principles in open source developments (Raymond, 1999), turned out to create most friction within this communal development of AQE. This was revealed in two observable instances. Firstly, the Kickstarter campaign's success involved the necessity to scale the production process. This in turn meant outsourcing the development of the final products to an external company and, with it, breaking an important link with OS principles that urges treating the users as co-developers. As noted in the study, in this process the users' perceptions of this project's underlying motivations clashed with those of the organisers. While the latter insisted on communal and open source values, the former saw them as business strategies of community appropriation.

The second instance relates to the AQE device and most importantly the open data it creates. While built on open principles, the AQE device differs from other open hardware projects, for example such as Nanode, the open microcontroller board that permits any application to be built upon it. The AQE device, on the other hand, has a number of added elements such as sensors, enclosures, and pre-programmed ways to transfer data. Thus, unlike the Nanode whose target users are most likely other open hardware hackers, AQE target users are air quality enthusiasts who might or might not have some programming skills. This fact in itself did not create friction between community members, rather it was the question relating to the pre-programmed component of this product. Sending data to the Pachube platform revealed the value of the project, and thus became the matter for communal concern. While friction is not necessarily a bad thing, it reveals different frameworks and perceptions at work. As noted by Bauwens (2012), it exposes the 'dual logic', which many community projects face today. On the one hand, the project organisers insisted on community' ownership and the open aspects of AQE network data, on the other, it was hard to hide the company's take-over by the LogMeIn, and changes that created in terms of the data platform use and services.

Yet, data and its governing principles were at the heart of the Pachube community's concerns. As noted above, the development of AQE device and most importantly the AQE network of citizen-owned devices, created a precedent for a public ownership of data and thus the base from which open data argument in IoT framework could be constructed. From such perspective, the AQE project could also be seen as a tool for *détournement* of the dominant IoT discourse or means of production by which the new space of Open IoT was created. As Lefebvre argued, 'diversion and production cannot be meaningfully separated' (Lefebvre, 1991:168).

This brings us to the methods of spatial practice. As noted already, Lefebvre made a clear distinction between the appropriation and practices of *détournement* (Lefebvre, 1991:167). Both these methods have been embraced in arts and open source practices. In open source the appropriation of existing code is at the core of coding practices, while the *détournement,* mastered by the *Situationists International,*[254] has similarly become an approach often explored in critical art practices. Again, while the AQE project might sit outside the traditional sphere of art, its contribution to the emerging Open IoT space is without doubt. Thus in this larger context, I argue, it had a similar effect as a graffiti message left on a city wall in 1968, to change context and to create a new meaning. Its role was not to break down power structures but rather to show that another way is possible[255] or in other words the project's alignment with more contemporary social struggles and efforts to develop alternative futures.

The methods of appropriation were best highlighted in the ways the community navigated both online and offline spaces. Besides the use of Wikis and mailing lists, they engaged with social media platforms, and in particular, they appropriated Meetup.com and Kickstarter.com not only to conduct their daily affairs, publish reports, and exchange updates, but also as a means to grow their community and supporter base. The meetup.com platform, an online service used to create groups that host local in-person events, was at the time popular in America among political campaigners, but was barely known in Europe. The same could be said

254See more on IS here: https://www.cddc.vt.edu/sionline/.

255The slogan 'Another world is possible' was embraced by anti-globalisation movements and became the motto for World Social Forum around 2001 https://en.wikipedia.org/wiki/World_Social_Forum.

about Kickstarter.com and its focus on crowdfunding. The use of these platforms enabled them to master the organisation across a number of geographically dispersed locations and at the same time embrace network self-organisation on the edges of the network. While the original purpose of meetup.com was to connect local interest groups for face-to-face events, the organisation of multiple meetups across different locations was an approach used by political campaigning. This approach was highlighted by the campaign organised for the presidential candidate Howard Dean in 2004, but also by the Occupy Movement in 2011. The use of these sites as tactics of campaigning, I argue, not only signals the appropriation of these sites for their own set of goals, but also this community's alignment with the social campaigning and direct-action character of their practice (Franks, 2003). Furthermore, as the meetup framework enveloped the physical space where the group's actions were realised, it became the public realm in which subjectivities of participants themselves could be transformed. As Zandbergen puts it 'the [AQE/IoT] meetups enabled a shared experience of detachment from the networks, roles, and institutions of daily life' (Zandbergen, 2017:557).

While meetup.com facilitated their actions and disclosure of 'who', both in terms of subjective and objective appearance, their use of the Kickstarter.com as a public online space disclosed the frictions that emerged from the contradictory forces embraced. The frictions in a context of AQE project foregrounded the struggles with the business framework that supported and facilitated it. As it has been argued, this corporate perspective of AQE project as one initiated by the incorporated Pachube start-up, can be linked to neoliberal business culture that emerged in the early to mid-1980s, with its reliance on 'hyper-socialized' (Turner, 2009) processes of manufacturing, exploration of new ways of organizing innovation, competition management and appropriation of 'playful' collaboration (see Zandbergen, 2017). From such perspective the AQE story might be viewed as yet another example of the neoliberal co-optation of the commons (Andrejevic 2009; LaDousa 2014; Terranova 2000; Zandbergen, 2017).

However, I argue here that the AQE project could also be seen as a case study that acts as a tool for *détourment* of the dominant IoT discourse. By offering insight into participants' own perceptions, roles, and the ways they went about collective actions; and by viewing their practice in a broader historical and social context, the political character of their action comes to the fore. The AQE project was a case study for open data commons and a symbolic resource of collaborative power (Bourdieu, 1998). Thus, I argue, in case of the Pachube community, the associating social and market capital combinatory approaches did not lead to the 'crowding out' of social contributions, but rather their emphasis of the sphere of the commons lead to underfunding and precarity in the community of contributors (see Bauwens, 2012). This is particularly relevant if we would consider the role played by the community organisers, the focus and energy they bring in organising communal events and, their role in ensuring the frequency of the interactions and feedback in communications.

However, the fluid nature of this community, as this study observed, permitted them to perform their different subjective identities, negotiate processes in public and sustain their future engagements in collaborative networks. This is best illustrated by the continuation of IoT monthly meetups in London, for example, and annual gatherings of Open IoT supporters. The legacy of Open IoT space[256] they produced is flourishing, as discussions on open data and data commons in IoT context persists (see for example: Mansell and Matheson, 2016; Blok, et al., 2017; ThingsCon, 2018). Thus, by considering this legacy of Pachube community it is safe to suggest that the value of practices at the edges of the dominant space is not only in their ability to innovate or to be critical of the dominant discourse, but also in a ways they can produce alternative views and spaces that foster the discourse in more open and public domain.

256On 2018 the Open IoT space was renewed online at http://iot.london/open-internet-of-things-definition.

8.

CONCLUSION

The aim of this thesis was to expand the view on the emerging Internet of Things phenomenon beyond the purely technological discourse that dominated the field at the start of second decade of the 21st century. By considering the historical developments and the emergence of the IoT discourse, the theoretical part of the thesis has suggested that the 'thing' perspective not only brings the fuzziness to the discourse, but also acts as a critique of a vision of network dominance as it brings back the focus on a local particulars, the heterogeneity and messiness of the physical world. Thus, by engaging with thinkers in the fields of social geography, phenomenology, and the studies of critical media and social practice, the theoretical part of this thesis has argued that one way to consider the impact of IoT developments could be through the analysis of changing perceptions of spatial configurations, and through the lens of social practice.

With that in mind, this thesis set out to interrogate the social conditions of the IoT system's development and, in particular, contributions made by artists, writers, and other early adopters of technology whose contributions are often overlooked by the mainstream analysts of later-stage developments. Highlighting these contributions was important in order to contextualise the study at the heart of this thesis that has addressed the community of developers and early adopters that rallied around the first IoT platform - Pachube (2007-2013). As the thesis has revealed, the democratisation of technologies and employment of methods prevalent in art and open source culture led to the emergence of the first IoT platform in the 21st century, which was developed not in a major, well-funded research centre of an established institution, but rather by a group of loosely-associated developers and artists who were previously engaged in exploring the critical aspects of technologies and applications of participatory design approaches in the contexts of interaction art and design.

The three-part study at the centre of this thesis, employing methods of ethnography and linguistic analysis, has explored not only their visions and perceptions of the emerging IoT domain but also their practice through analysis of the methods employed and the materialities produced. The thesis has revealed that through their advocacy and practice in this domain, they not only created a tangible and participatory IoT system, but also produced an Open IoT space where new discourse could flourish. Thus, the case study at the centre of this thesis is both intrinsic, as it has revealed the workings and intricacies of one group or community, and instrumental, as it has revealed the emerging issues related to the larger contexts of the IoT domain.

The linguistic analysis of participant speech and writings has disclosed their perceptions of this community's formation and of a broader IoT discourse. The community's fluid nature has often been articulated in a open framework, and sustained in a constant negotiation between subjective and objective viewpoints. The methods embraced by this group were perceived as a key descriptor that set them apart from the approaches of other developers and from a perceived dominant practice. The perceptions of the larger IoT domain have disclosed the prevalent role of network sensor devices in a reorientation of power and knowledge, the need for citizen participation in the creation of thicker layers of subjective data inputs, and the complexities involved in measurement and calibration processes. Furthermore, the linguistic analysis has unveiled the emergence of data discourse at the centre of the IoT phenomenon. Analysis has revealed not only the changing nature of data, but also the perceptions of data value and ownership, its public and private nature, and its spatial configuration which often reflects the spatial configurations and the entanglements of the physical world.

The ethnography of this community's practice and their chosen approaches not only revealed how online and offline spaces were navigated to further the community's aspirations to create an affordable IoT device and citizen-run air quality network, but also how, in the process, they created an opportunity for public discussion and a shared knowledge resource pool. With all of its shortcomings, the legacy of the AQE project suggests that the chosen approach of developing an open-source product in public view and in a collaborative manner not only set a precedent for a particular approach, but also created a common tool around which future discussions about air quality and the use of citizen tools could emerge. Furthermore, as highlighted in the discussion part of this thesis, the AQE project was also a case study for the open data argument, as this data represented that which had been created and owned by a citizen sensor network.

To conclude, the thesis not only provides an insight into the perceptions and practice of early IoT adopters, but also an opportunity to evaluate what constituted 'best practice'[257] in the field of the IoT and citizen science in the early 21st century. It provides a viewpoint from a particular point in time and space on issues related to IoT system implementation and the emergence of IoT data and Open IoT discourses.

8.1. Main Contributions

The contributions of this thesis are both theoretical and analytical. The theoretical contribution can be seen as one related to discourses that engage with an understanding of the impact technological systems have on the social world and vice versa. These would include STS, HCI, philosophy, social geography, social and media studies, and digital humanities. By engaging with both the technological and socio/spatial contexts of the emerging IoT phenomenon, this thesis diverged from the purely technological framework through which the IoT has usually been analysed. As one of the key research objectives of this thesis was to construct a more social understanding of the IoT phenomenon, the study turned to the ways the discourse of social history and phenomenological interpretations could be made more prominent. I

257See Zandbergen "The 2014 Smart City Event, organized with EU funding /-/ the Air Quality Egg (AQE) project, was mentioned as such a best-practice story" (2017:540), and Townsend (2015) for 'best practice' description.

have articulated how the emergence of the IoT phenomenon could be addressed from a perspective of the social and spatial practices of the early adopters, and the contributions they made at its trigger stage development. The thesis has discussed the dominant visions of the IoT discourse, and argued for the historic role of the early adopters, and then tied their contributions to the studies of spatial, social and cultural practice. I have made a strong argument, appropriate to these disciplines, for the importance of considering the technology in these contexts, and the importance of social practice to the realm of technology. In the current anthropocene era, this is particularly important as with this emerging technology we attempt to make the invisible visible. But we also want to make visible the meaningful and the meaningful actionable. To do so, we need to address the field of practice and politics governing each step of these developments.

The analytical findings of this thesis can be seen as contributing to two groups of disciplines: on the one hand to STS, HCI, the philosophy of technology, social geography, media studies and the digital humanities, and on the other hand, to the fields of phenomenology, linguistic anthropology, ethnographic studies and the emerging field of data and citizen science. This thesis has not only shown how the space of the IoT was constructed in practice, but also how much of it was constructed in the perceptions of its developers. I have provided evidence that the analysis of language can provide indications of perceptions: in this case, of social order and space extended by means of technology. The thesis has also provided corroborating evidence of changing perceptions of power relations brought about by the introduction of new actants in the field, such as the role played by the environment and by physical devices and the digital, real-time data they deliver. The analysis of spatial practice also offers an insight into the complexities involved, not only in adopting new ways of organising and managing social action and production processes, but also in the way the experience and spatial configurations of the physical world are reflected in the emerging space of the new actants. Furthermore, the thesis has provided insight into how the processes of collaboration, technological innovation and knowledge production can benefit the field of citizen science, and thus bring us closer to an understanding of environmental issues such as air quality and its meaning for our everyday actions. Thus the thesis has also made a substantial contribution to studies of collaborative practice, and the role they can play in shifting perceptions about the future world, and the ways we can act together.

8.2. Future Work

This thesis reveals a potential for much future work. There is a limited body of work on the study of perceptions in the context of the emerging IoT domain. While in recent years some social research has been done on IoT framework technologies, in particular in a context of near body tech and big data (Srnicek, 2017; Moore, 2018), there is still much work to be done in the context of environmental or urban studies. Furthermore, while this thesis goes some distance to arguing for the acknowledgement of a collaborative culture and of community-led peer learning processes in these areas of emerging technology, there are many possibilities for building upon both these points, both theoretically and analytically.

Given more time and space, it would be possible to extend the theoretical argument in Part 1, both in terms of the study of space extended by emerging technologies as well as their impact on the social world. There is a gulf emerging between early visions of the social and economic benefits of the IoT phenomenon and the approaches that many in the IoT industry have chosen to adopt, i.e. by focusing on the data-driven surveillance economy. The application of other theoretical approaches would also be a valuable way of reassessing the currently chosen path, not only in technological developments but in terms of social and political challenges that hinder current processes of adaptation, data interoperability and growing concerns for privacy. In addition, the emerging data discourse offers a rich field of enquiry. Of particular interest would be to further develop thinking on the data commons (a concept that was barely present in 2012) that would offer more coherent solutions to problems highlighted by the studies in this thesis. For example, if, as my study has suggested, social data is perceived to have a common value, how could the benefits of that value be placed back in the social realm?

There are also many directions to take regarding further analytical work that could draw on this thesis for its inspiration, foundation and theoretical orientation. One direction is to further explore ways to study perception through other language analysis theories and tools, such as using the computational methods of data corpus analysis or further exploring tools of conversational analysis. Likewise, the chosen application of action ethnography was a significant tool in the framework of this thesis; however, its ad-hoc nature meant that there was little space to assess the changes in perception that might be possible to evaluate if the subsequent follow-up interviews could be conducted. Another direction would be to consider a comparative study of the different approaches and contexts in which IoT technologies are developed. As my study has confirmed, geeks argue about technology, and they also argue through it; however, the affordances they build into the technology are not always adopted in the way they intended, as my study has also illustrated. Furthermore, as a field requires collaborations across many occupations, it would be interesting to explore inputs of different parties to the process of creativity and social rigour.

And finally, by capturing the actions and contributions of this one particular group of developers whose aspirations were rooted in alternative visions of what could possibly be imagined and built, the thesis has told a story of everyday struggles in the face of ongoing colonisation. These were explored by processes and changes in language and practice that occurred while the IoT transitioned from a speculative phenomenon into a commercial thing, or from a hacker space to a commercial one. By telling the story of this transformation, we can reclaim a space and revisit the ideas and ways that can motivate future actions. Thus, another way to develop this work further would be to seek out other yet untold stories of similar groups and struggles so that voices can be heard and stories not forgotten.

9

BIBLIOGRAPHY

Aarts, E., Harwig, R., and Schuurmans, M. (2002). Ambient Intelligence. In: Denning, P. (Ed.), *The Invisible Future: The Seamless Integration of Technology in Everyday Life.* McGraw-Hill, New York, pp. 235–250.

Aberer, K., Sathe, S., Chakraborty, D., Martinoli, A., Barrenetxea, G., Faltings, B., and Thiele, L. (2010). OpenSense: Open Community Driven Sensing of Environment. In Proceedings of *ACM SIGSPATIAL International Workshop on GeoStreaming*. ACM, pp. 39–42.

Agar, M. (1982). Towards an Ethnographic language. *American Anthropologist*, 84(4), pp. 779–795.

Ågerfalk, P. J., and Fitzgerald, B. (2008). Outsourcing To An Unknown Workforce: Exploring Opensourcing. *MIS Quarterly*, 32(2), pp. 385–409.

Agha, A. (2006). *Language and Social Relations*. New York: Cambridge University Press.

Agrawal, S., and Das, M. L. (2011). Internet of Things – A Paradigm Shift of Future Internet Applications. In *Engineering (NUiCONE).* Nirma University International Conference, IEEE, pp. 1-7.

Agrawal, A., Catalini, C., and Goldfarb, A. (2014). Some simple economics of crowdfunding. *Innovation Policy and the Economy*, 14(1), pp. 63-97.

Agre, P. E. (2002). Real-Time Politics: The Internet and the Political Process. *The Information Society*, 18(5), pp. 311-331.

Ahearn, L. M. (2001). Language and Agency. *Annual Review of Anthropology*, 30(1), pp. 109–37.

Aigrain, P. (2014). *Sharing: Culture and the Economy in the Internet Age.* Amsterdam: University Press.

Alabdulkarim, L., Lukszo, Z, amd Fens, T. (2012). Acceptance of Privacy-Sensitive Technologies: Smart Metering Case in The Netherlands. *Third International Engineering Systems Symposium CESUN 2012, Delft University of Technology.*

Albrecht, K, and McIntyre, L. (2005). *Spychips: How Major Corporations and Government Plan to Track Your Every Move with RFID*, Thomas Nelson.

Allen, P.D. (2015). *Cloud Computing 101: A Primer for Project Managers*. US: CreateSpace Independent Publishing Platform.

Almond, D., Chay, K., and Lee, D. (2005). The Costs of Low Birth Weight. *The Quarterly Journal of Economics,* 102(3), pp. 1031–1083.

Alrayes, F., and Abdelmoty, A. (2016). Towards Location Privacy Awareness on Geo-Social Networks. In *10th International Conference on Next Generation Mobile Applications, Security and Technologies IEEE (NGMAST),* pp. 105-114.

Amin, A. (2002). Spatialities of globalisation. *Environment and Planning*, 34, pp. 385 – 399.

Amsterdamska, O. (1990). 'Surely You're Joking, Mr Latour!' *Science, Technology, Human Values*, 15(4), pp. 495-504.

Arendt, H. (1958). The Modern Concept of History. *The Review of Politics,* 20(4), pp. 570–590.

Arendt, H. (1998). (First Published 1958) *The Human Condition.* Chicago/London: The University of Chicago Press.

Armstrong, A., and Hagel III, J. (2009). The real Value of Online Communities. In: Lesser, E., Fontaine, M., and Slusher, J. (Eds.) *Knowledge and Communities.* London: Routledge.

Ashton, K. (2009). That ‘internet of things’ thing. *RFiD Journal*, 22(7), pp. 97-114.

Atzori, L., Iera, A., and Morabito, G. (2010). The internet of things: A survey. *Computer networks*, 54(15), pp. 2787-2805.

Axel, B. K. (2006). Anthropology and the new technologies of communication. *Cultural Anthropology*, 21(3), pp. 354-384.

Axelrod, R. (2006). *The Evolution of Cooperation* (Revised ed.). Perseus Books Group, National Bureau Of Economic Research.

Austen, K. (2015). Pollution patrol. *Nature*, 517(7533), p.136.

Azar, J., Schmalz, M. C., & Tecu, I. (2018). Anticompetitive effects of common ownership. *The Journal of Finance*, *73*(4), 1513-1565.

Bakhtin, M. M. (1981). *The Dialogic Imagination*. (C. Emerson & M. Holquist, Eds.). Austin and London: University of Texas Press.

Baldwin, C., Hienerth, C., and Von Hippel, E. (2006). How user innovations become commercial products: A theoretical investigation and case study. *Research policy*, 35(9), pp. 1291-1313.

Balzano, L., and Nowak, R. (2007). Blind calibration of sensor networks. In *Proceedings of the 6th international conference on Information processing in sensor networks, ACM*, pp. 79-88.

Bandara, P., and, D. (2018 Carpenter). Planetary electromagnetic pollution: it is time to assess its impact. *The Lancet*, *2* (12). pp. 512-514.

Barbrook, R. (1995). *Media Freedom.* London: Pluto Press.

Barbrook, R., and Cameron, A. (1995). The Californian Ideology. In *Science as Culture (1996)*, No 26, 6(1), pp. 44-72.

Barbrook, R. (2007). *Imaginary Futures*. London: Pluto Press.

Barbrook, R. (2016). *The Net Bill Of Rights: digital citizenship in the 21st century information society*. Cybersalon.

Barringer, F. (2011). New Electricity Meters Stir Fears. *The New York Times*. Retrieved on 1 November 2018 from http://www.nytimes.com/2011/01/31/science/earth/31meters.html?_r=2 and http://agriculturedefensecoalition.org/sites/default/files/file/pge_smart_meters/18N%202011%20New%20Electricity%20SMART%20Meters%20Stirs%20Fears%20January%2030,%202011%20NYTimes%20Entire%20Article.pdf

Barnatt, C. (2010). *A Brief Guide to Cloud Computing: An essential guide to the next computing revolution.* London: Robinson.

Batty, M. (1997). Virtual Geography. *Futures*, 29(4/5), pp. 337–352.

Bauwens, M. (2012). The Collaborative Economy. *P2P Foundation*. Retrieved on 1 May 2017, from https://www.ncbi.nlm.nih.gov/

Bauwens, M., Kostakis, V., Troncoso, S., and Utratel, A. M. (2017). Commons Transition and P2P: a primer. Retrieved on 1 May, 2017, from https://blog.p2pfoundation.net/commons-transition-and-p2p-a-primer/2017/05/09

Bauwens, M., Mendoza, N., and Iacomella, F. (2012). Synthetic overview of the collaborative economy. Chiang Mai: P2P Foundation. Retrieved on 14 August 2014 from https://wiki.p2pfoundation.net/Synthetic_Overview_of_the_Collabora- tive_Economy

Beaulieu, A. (2004). Mediating ethnography: objectivity and the making of ethnographies of the Internet. *Social Epistemology*, 18(2-3), pp. 139–163.

Becker, B., and Wehner, J. (2001). Electronic Networks and Civil Society: Reflections on Structural Changes in the Public Sphere. *Culture, technology, communication: Towards an intercultural global village*, p. 67.

Beckwith, D., and Lopez, L. (1997). Community Organizing: People Power from the Grassroots. Retrieved on 11 September 2016 from https://comm-org.wisc.edu/papers97/beckwith.htm

Behmann, F., and Wu, K. (2015). *Collaborative Internet of Things (C-IoT): For Future Smart*

Connected Life and Business. UK: John Wiley & Sons.

Bell, M. L., and Davis, D. L. (2001). Reassessment of the lethal London fog of 1952: Novel indicators of acute and chronic consequences of acute exposure to air pollution. *Environmental Health Perspectives*, 109(s3), pp. 389–394.

Belleflamme, P., Lambert, T., and Schwienbacher, A. (2010). Crowdfunding: Tapping the Right Crowd. *CORE Discussion Paper,* No. 2011/32.

Belleflamme, P., Lambert, T., and Schwienbacher, A. (2013). Crowdfunding: Tapping the right crowd. *Journal of Business Venturing.* Retrieved on 1 May 2017 from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1578175

Benbasat, I., and Zmud, R. W. (2003). The Identity Crisis Within the IS Discipline: Defining and Communicating The Discipline's Core Properties. *MIS Quarterly* 27(2), pp. 183-194.

Benford, R. D., and Snow, D. A. (2000). Framing Processes and Social Movements: An Overview and Assessment. *Annual Review of Sociology,* 26, pp. 611–639.

Benkler, Y. (2006). *The Wealth of Networks: How Social Production Transforms Markets and Freedom.* New Haven: Yale University Press.

Bennett, J. (2004). The force of things steps toward an ecology of matter. *Political theory*, *32*(3), pp. 347-372.

Berger, J., Zelditch, M., Anderson, B., and Cohen, B.P. (1972). Structural aspects of distributive justice: A status value formulation. *Sociological theories in progress*, *2*, pp. 119-146.

Bergström, F. (2016). Data is the new gold. Retrieved on 1 May 2017 from https://www.tieto.com/insights-and-opinions/data-is-the-new-gold

Bergquist, M., and Ljungberg, J. (2001). The power of gifts: organizing social relationships in open source communities. *Information Systems Journal*, 11, pp. 305–320.

Berners-Lee, T. (2017). Tim Berners-Lee: I invented the web. Here are three things we need to change to save *The Guardian*, Retrieved on 1 May 2017 from https://www.theguardian.com/technology/2017/mar/11/tim-berners-lee-web-inventor-save-internet

Bhaskar, R. (2008). *A Realist Theory of Science.* London: Routledge.

Black, I., and White, G. (2013). Collaborative creativity and New Media Arts. In *Proceedings of CHI'13.*

Bleecker, J. (2006). *A Manifesto for Networked Objects - Cohabiting with Pigeons, Arphids and Aibos in the Internet of Things*. Retrieved on 1 May 2017 from http://nearfuturelaboratory.com/files/WhyThingsMatter.pdf

Blok, A., Marquet, C., Courmont, A., Minor, K., and Young, M. (2017). Data Platforms and Cities. *TECNOSCIENZ A Italian Journal of Science & Technology Studies 8 (2) pp. 175-219.*

Brabham, D. C. (2008). Crowdsourcing as a Model for Problem Solving: An Introduction and Cases. *Convergence: The International Journal of Research into New Media Technologies*, 14(1), pp. 75–90.

Brewer, J., and Hunter, A. (1989). *Multimethod research: A synthesis of styles.* Newbury Park, CA: Sage Publications, Inc.

Brine, K. R., and Poovey, M. (2013). From Measuring Desire to Quantifying Expectations: A Late Nineteenth-Century Effort to Marry Economic Theory and Data. In Gitelman, L. (Ed.), *"Raw Data" Is an Oxymoron,* pp. 61-75.

Bohm, G. M. (1981). Air pollution and lung cancer. *Cancer Detection and Prevention*, 5(4), pp. 371–374.

Bonaccorsi, A., and Rossi, C. (2003). Why Open Source software can succeed. *Research Policy, 32,* pp. 1243-1258.

Boomen, M. van den, and Schafer, M. (2005). Will the revolution be open-sourced? How open source travels through society. In Wynants, M., & Cornelis, J. (Eds.) *How Open is the Future? Economic, Social & Cultural Scenarios inspired by Free & Open-Source Software,* EU: VUB Brussels

University Press, pp.31-66.

Borenstein, S. (2014). With their mark on Earth, humans may name are, too. *Associated Press.* Retrieved on 14 October 2014 from http://apnews.excite.com/article/20141014/us-sci-age-of-humans-961f501908.html

Bourdieu, P. (1990). *The Logic of Practice.* Cambridge: Polity Press.

Bourdieu, P. (1998). *Practical Reason: On the Theory of Action.* Stanford, California: Stanford University Press.

Brown, J. S., Duguid, P., and Haviland, S. (1994). Toward informed participation: Six scenarios in search of democracy in the information age. *Aspen Institute Quarterly*, 6(4), pp. 49–73.

Brock, D. L. (2001). The Electronic Product Code (EPC) A Naming Scheme for Physical Objects. *Auto-ID Labs White Paper.*

Brook, R. D., Franklin, B., Cascio, W., Hong, Y., Howard, G., Lipsett, M., and Tager, I. (2004). Air pollution and cardiovascular disease - A statement for healthcare professionals from the expert panel on population and prevention science of the American Heart Association. *Circulation*, 109(21), pp. 2655–2671.

Brook, R. D., Rajagopalan, S., Pope, C. A., Brook, J. R., Bhatnagar, A., Diez-Roux, A. V., and Peters, A. (2010). Particulate matter air pollution and cardiovascular disease an update to the scientific statement from the American Heart Association. *Circulation*, 121(21), pp. 2331–2378.

Bröring, A., Schmid, S., Schindhelm, C. K., Khelil, A., Kabisch, S., Kramer, D., and López, T. E. (2017). Enabling IoT ecosystems through platform interoperability. *IEEE software*, *34*(1), 54-61.

Buchstein, H. (1997). Bytes that bite: The Internet and deliberative democracy. *Constellations* 4(2), pp. 248–263.

Burkhardt, J., Schaeck, T., Henn, H., Hepper, S., and Rindtorff, K. (2001). *Pervasive computing: technology and architecture of mobile Internet applications*. Boston, MA: Addison-Wesley Longman Publishing Co., Inc.

Burrell, J. (2009). The Field Site as a Network: A Strategy for Locating Ethnographic Research. *Field Methods*, 21(2), pp. 181–199.

Butcher, M. (2011, July 20). LogMeIn acquires ‘Internet of Things’ Startup Pachube for $15m in Cash. *TechCrunch.* Retrieved on 2 August 2016, from http://techcrunch.com

Callon, M. (1986). Some elements of a sociology of translation: domestication of the scallops and the fishermen of St Brieuc bay. In Law, J. (Ed.), *Power, Action and Belief.* London: Routledge and Kegan Paul, pp. 196 -233.

Castells, M. (1996). *The Rise of the Network Society*. London: Blackwell.

Castells, M. (1999). Grassrooting the space of flows. *Urban Geography*, 20(4), pp. 294-302.

Centre for International Governance Innovation & Ipsos (2018). 2018 CIGI-Ipsos Global Survey on Internet Security and Trust. Retrieved on 1 January 2019 from https://www.cigionline.org/internet-survey-2018

CERP-IoT (2009). Internet of Things Strategic Research Roadmap. Retrieved on 10 May 2010 from http://www.grifs-project.eu/data/File/CERP-IoT%20SRA_IoT_v11.pdf.

Chay, K. Y., and Greenstone, M. (2003). The Impact of Air Pollution on Infant Mortality: Evidence from Geographic Variation in Pollution Shocks Induced by a Recession. *The Quarterly Journal of Economics*, 118(3), pp. 1121–1167.

Chen, Y. (2012). S7-1 Challenges and Opportunities of Internet of Things. *S7-1*, pp. 383–388.

Cheng, Y., Xu, C., Yang, Y., Ying, L., Su, P., and Feng, D. (2014). Automated User Profiling in Location-based Mobile Messaging Applications. In *IEEE 13th International Conference on Trust, Security and Privacy in Computing and Communications*, pp. 18-26.

Christidis, K., and Devetsikiotis, M. (2016). Blockchains and smart contracts for the internet of things. *Ieee Access*, *4*, pp. 2292-2303.

Chui, M., Löffler, M., and Roberts, R. (2010). The Internet of things. *McKinsey Quarterly*, No2, 291(2), pp. 76–81.

Clark, N. A., Demers, P. A., Karr, C. J., Koehoorn, M., Lencar, C., Tamburic, L., and Brauer, M. (2010). Effect of Early Life Exposure to Air Pollution on Development of Childhood Asthma. *Environmental Health Perspectives,* 118(2), pp. 284–290.

Coleman, E. G. (2010). Ethnographic Approaches to Digital Media. *Annual Review of Anthropology,* 39(1), pp. 487–505.

Combetto, M. (2006). Affective Systems in Human-Centric Intelligent Environments. In *Proceedings of WP9 Workshop on Innovative Approaches for Evaluating Affective*.

Confino, J. (2015). Public trust in business hits five-year low. Retrieved on 1 January 2019 from https://www.theguardian.com/sustainable-business/2015/jan/21/public-trust-global-business-government-low-decline

Corby, T. (2005). *Network Art: Practices and Positions.* London: Routledge.

Corino, A. G., Shingleton, D., and Speed, C. (2011). Pervasive memory, locative narratives. *REM: Research on Education and Media*, Vol 2.

Cox, S. J. B. (1985). No Tragedy on the Commons. *Environmental Ethics,* 7, pp. 49–62.

Cox, A. M. (2005). What are communities of practice? A comparative review of four seminal works. *Journal of Information Science*, 31, pp. 527–540.

Covaleski, M. A., Dirsmith, M. W., Heian, J. B., and Samuel, S. (1998). The calculated and the avowed: Techniques of discipline and struggles over identity in Big Six public accounting firms. *Administrative Science Quarterly*, pp. 293-327.

Cowley, S., Goldman, D., Pepitone, J., Segall, L., and Smith, O. (2012). Kickstarter's Top 50 Projects: When They Shipped. *CNNMoney.*

Crang, M., and Cook, I. (2007). *Doing Ethnographies*. Los Angeles, CA: SAGE.

Crall, A. W., Jordan, R., Holfelder, K., Newman, G. J., Graham, J., and Waller, D. M. (2013). The impacts of an invasive species citizen science training program on participant attitudes, behaviour, and science literacy. *Public Understanding of Science,* 22(6), pp. 745–64.

Crawford, K., and boyd, D. (2012). Critical Questions For Big Data. *Information, Communication & Society,* 15(5), pp. 662–679.

Crawford, K., Miltner, K., and Gray, M. L. (2014). Critiquing Big Data: Politics, Ethics, Epistemology Special Section Introduction. *International Journal of Communication*, 8, pp. 1663–1672.

Crutzen, P. J. and E. F. Stoermer (2000). The 'Anthropocene'. *Global Change Newsletter. 41***,** pp. 17–18.

Cuff, D., Hansen, M., and Kang, J. (2008). Urban sensing: out of the woods. *Communications of the ACM*, *51*(3), pp.24-33.

Currie, J., and Neidell, M. (2004). Air Pollution and infant health: What can we learn from California’s recent experience? *The Quarterly Journal of Economics*, 120(3), pp. 1003-1030.

Cvetanovi, S., Despotovi, D., and Mladenovi, I. (2012). The Concept of Technological Paradigm and the Cyclical Movement of the Economy. *Economics and Organisation*, 9, pp. 149-159.

Damek-Poprawa, M., and Sawicka-Kapusta, K. (2003). Damage to the liver, kidney, and testis with reference to burden of heavy metals in yellow-necked mice from areas around steelworks and zinc smelters in Poland. *Toxicology*, 186(1-2), pp. 1-10.

Danish National Environmental Research Institute, Center for Clear Air Policy, and Milieu Ltd. (2004). Comparison of the EU and US Air Quality Standards and Planning Requirements. Report.

Davies, A. (2018). Are health apps actually bad for your health?, *BBC*, Retrieved on 1 November 2018 from https://www.bbc.co.uk/bbcthree/article/9fe47476-ad1f-414c-a925-cf078a2145a8

Davis, D. L., Bell, M. L., and Fletcher, T. (2002). A Look Back at the London Smog of 1952 and the Half Century Since. *Environmental Health Perspectives*, 110(12), pp. 734–735.

De Angelis, M. (2007). *The beginning of History: Value Struggles and Global Capital.* London, Pluto Press.

DeLanda, M. (2002). *Intensive Science and Virtual Philosophy*, London: Continuum.

Delamont, S. (2004). Ethnography and participant observation, In: Seale C, Gobo G, Gubrium, J. (Eds), *Qualitative Research Practices.* London: SAGE, pp. 217–229.

Delamont, S. (2007). Arguments against Auto-Ethnography. Paper presented at the British Educational Research Association Annual Conference, *Institute of Education,* University of London.

Deleuz, G., and Guattari, F. (1988). *A Thousand Plateaus.* Trans. Brian Massumi. Minneapolis, MN: University of Minnesota Press.

Deleuz, G. (2014). *Difference and Repetiti*on. UK/USA: Bloomsbury Academic, 2nd ed.

d'Entreves, M. P. (2016). *Hannah Arendt.* The Stanford Encyclopedia of Philosophy. Retrieved on 1 November 2018 from https://plato.stanford.edu/entries/arendt/

Department for Environment Food & Rural Affairs (2017). AQEG advice on the use of 'low-cost' pollution sensors. Retrieved on 12 December 2017 from https://uk-air.defra.gov.uk/library/aqeg/pollution-sensors.php

Desai, P., Sheth, A., and Anantharam, P. (2015, June). Semantic gateway as a service architecture for iot interoperability. In *Mobile Services (MS), 2015 IEEE International Conference.* pp. 313-319.

Dikeç, M. (2012). Space as a mode of political thinking Mustafa. *Geoforum*, 43, pp. 669–676.

Dittus, M. S. (2012). The Cosm Sensor Data Set Data Integration of a Sensor Commons (Dissertation). UCL, UK. Retrieved on 14 August 2014 from http://dekstop.de/temp/dissertation/Martin_Dittus-Cosm_Data-20120908.pdf

Dockery, D. W., and Pope, C. A. III. (1994). Acute respiratory effects of particulate air pollution. *Annual Review of Public Health*, 15(1), pp. 107–132.

Dohr, a., Modre-Opsrian, R., Drobics, M., Hayn, D., and Schreier, G. (2010). The Internet of Things for Ambient Assisted Living. *Seventh International Conference on Information Technology: New Generations,* pp. 804–809.

Dolphijn, R., and Van der Tuin, I. (2012). *New Materialism: Interviews & Cartographies.* Michigan: Open Humanities Press.

Dolin, R. A. (2006). Deploying the "Internet of things". In *International Symposium on Applications and the Internet, SAINT 2006.* pp. 4-219.

Dosi, G. (1982). Technical Paradigms and Technological Trajectories: A Suggested Interpretation of the Determinants of Technical Change. *Research Policy,* 2(3), pp. 147–62.

Doukas, C. (2012). Part 8 - Introducing Cosm As A Cloud Service: Introduction to basic Cosm concepts. In *Building Internet of Things.* CreateSpace Independent Publishing Platform.

Doukas, C. (2012). *Building Internet of Things. Part 1.* USA:CreateSpace Independent Publishing Platform.

Duranti, A. (1994). *From grammar to politics: linguistic anthropology in a Western Samoan village.* California: University of California Press.

Duranti, A. 2003. Language as culture in US anthropology. *Current Anthropology. 44* (3), pp. 323-335

Duranti, A. (2004). *History Of Linguistic Anthropology.* Malden, MA: Blackwell.

Duranti, A. (2001). Linguistic Anthropology. *International Encyclopedia of the Social & Behavioral Sciences*, pp. 8899–8906.

Duranti, A. (2010). *Linguistic anthropology*. New York: Cambridge University Press.

Eckert, P. (2000). *Linguistic Variation as Social Practice: The Linguistic Construction of Identity in Belten High, Malden.* MA: Blackwell Publishers.

Elen, B., Theunis, J., Ingarra, S., Molino, A., Van den Bossche, J., Reggente, M., and Loreto, V.

(2012). The EveryAware SensorBox: a tool for community-based air quality monitoring. *Paper presented at the Sensing a Changing World.*

Ellingson, S. (1995). Understanding the dialectic of discourse and collective action: Public debate and rioting in antebellum Cincinnati. *American Journal of Sociology,* 101(1), pp. 100-144.

Ellis, C. S., and Bochner. A. (2000). Autoethnography, Personal Narrative, Reflexivity: Researcher as Subject. In Denzin, N., and Lincoln, Y., (Eds.), *The Handbook of Qualitative Research*. Sage, pp. 733-768.

EPoSS (2009). *Internet of Things - An action plan for Europe.* Commission Of The European Communities.

Erl, T., Puttini, R., and Mahmood, Z. (2013). *Cloud Computing: Concepts, Technology & Architecture.* USA: Prentice Hall.

Estrin, D., Culler, D., and Srivastava, M. (2004). Guest editors' introduction: Overview of sensor networks. *Computer*, *37*(8), pp. 41-49.

Etter, V., Grossglauser, M. and Thiran, P. (2013). Launch hard or go home!: predicting the success of kickstarter campaigns. In *Proceedings of the first ACM Conference on Online Social Networks,* pp. 177-182.

European Environmental Agency (2015). Air quality in Europe: 2015 report. Retrieved on 1 August 2016 from http://www.eea.europa.eu/publications/air-quality-in-europe-2015.

Evans, D. (2011). The Internet of Things: How the next evolution of the Internet is changing everything. *CISCO white paper,* 1, pp. 1-11.

Evans, D.S. and Leighton, L.S. (1989). Some empirical aspects of entrepreneurship. *The American Economic Review*, 79(3), pp. 519-535.

Evelyn, J. (1661). Fumifungium: or the Inconvenience of the Aer and Smoake of London Dissipated. In Staniforth, S. (Ed.), *Historical Perspectives on Preventive Conservation.* Getty Conservation Institute. pp. 262-269.

Fairclough, N. (1995). *Critical discourse analysis: The Critical Study of Language*. London: Addison Wesley Publishing Company.

Fleisch, E. (2010). What is the Internet of Things? What is the Internet of Things - An Economic Perspective. *Auto-ID Labs White Paper* WP-BIZAPP-053

Fingas, J. (2018). Alexa is randomly laughing, and it's creepy as hell. Retrieved on 2 December 2018 from https://www.engadget.com/2018/03/07/amazon-is-fixing-alexa-creepy-laughter/

Fisher, J. B., & Fortmann, L. (2010). Governing the data commons: Policy, practice, and the advancement of science. *Information & management*, *47*(4), 237-245.

Fogel, R. W. (1986). Physical growth as a measure of the economic well-being of populations: the eighteenth and nineteenth centuries. In Falkner, F., and Tanner, M. J. (Eds.), *Human Growth: A Comprehensive Treatise,* pp. 263–281. New York: Plenum.

Forrest, C. (2017). Online shoppers are losing trust in e-commerce, study finds. Retrieved on 1 January 2019 from https://www.techrepublic.com/article/online-shoppers-are-losing-trust-in-e-commerce-study-finds/

Forsey, M. G. (2010). Ethnography as participant listening. *Ethnography,* 11(4), pp. 558–572.

Foth, M., Choi, J. H., and Satchell, C. (2011). Urban informatics. *Proceedings of the ACM 2011 Conference on Computer Supported Cooperative Work - CSCW '11*, p. 1.

Foucault, M. (1990). *History of Sexuality.* London*:* Pinguin Books.

Foucault, M. (1972). [1969]. *The Archaeology of Knowledge.* (Tr. Smith, S.A). London: Tavistock.

Fox, S. (2000). Communities of practice, Foucault and actor-network theory. *Journal of Management Studies*, 37(6), pp. 853–867.

Franks, B. (2003). Direct Action Ethic. *Anarchist Studies* 11, (1), pp. 13–41.

Freeman, C. (1974). *The Economics of Industrial Innovation.* Harmondsworth: Pinguin Books.

Freeman, C. (1991). Innovation, Changes of Techno-Economic Paradigm and Biological Analogies in Economics. In: *Revue économique,* 42(2), pp. 211-232.

Freeman, C. (2000). *High Tech and High Heels in the Global Economy: Women, Work and Pink-Collar Identities, Durham.* NC: Duke University Press.

Frederick, H. (1993). Computer networks and the emergence of global civil society. In Harasim, M. L. (Ed.), *Global networks: Computers and international communication*, Cambridge: MIT Press, pp. 283–295.

Friedman, T. (2013). Welcome to the Sharing Economy. *The New York Times.* Retrieved on 25 July 2013 from http://www.nytimes.com/2013/07/21/opinion/sunday/friedman-welcome-to-the-sharing-economy.html?pagewanted=all

Fuller, M. (2003). *Behind the blip: Essays on the culture of software.* New York: Autonomedia.

Fuller, M. (2005). *Media ecologies.* Cambridge, MA: MIT Press.

Fuller, M. (2008). *Software studies: A lexicon.* Cambridge, MA: MIT Press.

Gabrys, J. (2011). *Digital Rubbish: A natural history of electronic*s. USA: University of Michigan Press.

Gabrys, J. (2016). Re-Thingifying The Internet Of Things, In Starosielski, N., and Walker, J. (Eds.) *Sustainable Media: Critical Approaches to Media and Environment*, Routledge, pp. 180-195.

Galloway, A. R. (2004). *Protocol: How control exists after decentralization*. Cambridge, MIT Press.

Galloway, A. R. (2012). The Poverty of Philosophy: Realism and Post-Fordism. *Critical Inquiry*, 39, pp. 347–366.

Galloway, S. (2017). *The Four: The Hidden DNA of Amazon, Apple, Facebook and Google*. US: Bantam Press.

Gamson, W. A. (1992). *Talking politics*. USA: Cambridge university press.

Gamson, W. A., and Modigliani, A. (1989). Media discourse and public opinion on nuclear power: A constructionist approach. *American Journal of Sociology*, 95(1), pp. 1-37.

Gardiner, M. E. (2000). *Critiques of Everyday Life*. London, Routledge.

Garvey, E. G. (2013). “facts and FACTS”: Abolitionists’ Database Innovations. In Gitelman, L. (Ed.), “*Raw Data” Is an Oxymoron,* pp. 89-102.

Geertz, C. (1973). *The Interpretation of Cultures.* NY: Basic Books.

Geertz, C. (1993). *The Interpretation of Cultures.* London: Fontana Press.

Gerber, E., Hui, J., and Kuo, P. (2012). Crowdfunding: Why People are Motivated to Post and Fund Projects on Crowdfunding Platforms. *Design, Influence, and Social Technologies Workshop at Computer Supported Cooperative Work.*

Gershenfeld, N. (1999). *When Things Start to Think.* Philadelphia: Cornet Books.

Ghosh, R. A. (Ed.) (2005). *CODE: Collaborative Ownership and the Digital Economy*. Cambridge, MA: MIT Press.

Gibson, W. (1984). *Neuromancer.* New York: ACE.

Gilbert, J. (2014). *Common Ground: Democracy and Collectivity in an Age of Individualism*. London: Pluto Press.

Gitelman, L., and Jackson, V. (2013). Introduction. In Gitelman, L. (Ed.), “*Raw Data” Is an Oxymoron,* Cambridge, MA: The MIT Press, pp. i – 14.

Gitlin, T. (1980). *The whole world is watching: Mass media in the making and unmaking of the new left*. California: University of California Press.

Gochfeld, M., and Goldstein, B. D. (1999). Lesson in Environmental health in the twentieth century. *Annual Review of Public Health*, 20(1), pp. 35–53.

Gollan, J., De Bruyn, L. L., Reid, N., and Wilkie, L. (2012). Can volunteers collect data that are comparable to professional scientists? A study of variables used in monitoring the outcomes of ecosystem rehabilitation. *Environmental Management*, 50(5), pp. 969–78.

Goffman, E. (1990). *The presentation of self in everyday life.* New York: Penguin Books; 1959.

Goffman, E. (1974). *Frame analysis: An essay on the organization of experience*. Harvard University Press.

Goffman, E. (1981). *Forms of Talk.* Philadelphia: University of Pennsylvania Press.

Goriunova, O. (2012). *Art Platforms and Cultural Production on the Internet*. New York: Routledge.

Graham, S. (1997). Liberalized utilities, new technologies, and urban social polarization: the UK case. *European Urban and Regional Studies* 492, pp.135-50.

Graham, S., and Marvin, S. (2002). *Telecommunications and the City: Electronic Spaces, Urban Places*. London: Routledge.

Graham, S. (1998). The end of geography or the explosion of place? Conceptualizing space, and information technology. *Progress in Human Geography,* 22, pp.165-185.

Grønbæk, I. (2008). Connecting Objects in the Internet of Things. *Telektronikk,* p.2.

Grossman, D. (2017). "Right to Repair" Is About a Whole Lot More Than iPhones. Retrieved on 12 December 2017 from http://www.popularmechanics.com/technology/infrastructure/a25246/right-to-repair-legislation-under-fire-in-nebraska/

Green, C. (2012). Trusted and Being Trusted in the Sharing Economy. *Forbes.*Retrieved on 1 Nov 2018 from https://www.forbes.com/sites/trustedadvisor/2012/05/02/trusting-and-being-trusted-in-the-sharing-economy/

Greenfield, A. (2013). *Against smart city*. New York City: Do project.

Gubbi, J., Buyya, R., Marusic, S., and Palaniswami, M. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Generation Computer Systems*, 29(7), pp. 1645–1660.

Guinard, D., Trifa, V., Mattern, F., and Wilde, E. (2011). 5 From the Internet of Things to the Web of Things: Resource Oriented Architecture and Best Practices. In Harrison, M., Michahelles, F., and Uckelmann, D. (Eds.) *Architecting the Internet of Things.* Springer. pp. 1–33.

Guinard, D., Trifa, V., and Wilde, E. (2010). *Architecting a mashable open world wide web of things*. ETH, Department of Computer Science.

Habermas, J. (1996). *Between facts and norms: Contributions to a discourse theory of law and democracy.* Cambridge: Polity.

Habermas, J. (2002). *The structural transformation of the public sphere: An inquiry into a category of bourgeois society.* Cambridge: Polity.

Hachem, S., Teixeira, T., and Issarny, V. (2011). December. Ontologies for the internet of things. In *Proceedings of the 8th Middleware Doctoral Symposium, ACM*, p. 3.

Hacking, I. A. N. (2006). *Kinds of People: Moving Targets.* London: British Academy Lecture.

Haller, S. (2010). The Things in the Internet of Things. *Internet of Things Conference 2010,* Tokyo, Japan.

Haller, S. (2010). The things in the internet of things. At the *IoT 2010, Tokyo, Japan*, p. 26.

Hannemyr, G. (1999). Technology and pleasure: Considering hacking constructive. *First Monday*, 4(2).

Hansmann, U., Merk, L., Nicklous, M. S., and Stober, T. (2003). *Pervasive computing: The mobile world*. Springer Science & Business Media.

Haque, U. and Borden, E. (2011). Data and Owner. *Volume, 28,* pp. 156-157.

Halpin, P. N., Read, A. J., Best, B. D., Hyrenbach, K. D., Fujioka, Coyne, E. M. S., Crowder, L. B., Freeman, S. A., and Spoerri, C., (2006). OBIS-SEAMAP: developing a biogeographic research data commons for the ecological studies of marine mammals, seabirds, and sea turtles. *Marine Ecology Progress Series*, 316, pp. 239–246.

Haraway, D. (1991). A cyborg manifesto: science, technology, and socialist-feminism in the late twentieth century. In Haraway, D. (Ed.), *Simians, Cyborgs and Women: The Reinvention of Nature*, NYC: Routledge. pp. 149-181.

Hardaker, C. (2010). Trolling in asynchronous computer-mediated communication : From user discussions to academic definitions. *Journal of Politeness Research*, 6(2), pp. 215–242.

Hardin, G. (2001) (orig. 1968). The Tragedy of the Commons. *The Social Contract*, pp. 26–35.

Hardy, C., Phillips, N., and Lawrence, T. (1998). Distinguishing trust and power in interorganizational relations: Forms and facades of trust. *Trust within and between organizations*, pp. 64-87.

Harman, G. (2012). Object-Oriented France: The Philosophy of Tristan Garcia. Retrieved on 11 December 2012, from http://www.berfrois.com/2012/07/in-something-else-in-something-else/

Harvey, D. (2000). *Spaces of Hope.* Edinburgh: Edinburgh University Press.

Harvey, D. (2005). *A Brief History of Neoliberalism*. Oxford: Oxford University Press.

Havlin, S., Kenett, D. Y., Ben-Jacob, E., Bunde, A., Cohen, R., Hermann, H., Kantelhardt, J. W., Kertész, J., Kirkpatrick, S., Kurths, J., and Portugali, J. (2012). Challenges in network science: Applications to infrastructures, climate, social systems and economics. *The European Physical Journal Special Topics*, 214, pp. 273-293.

Hayano, D. (1979). Auto-ethnography: Paradigms, problems, and prospects. *Human organization*, 38(1), pp. 99-104.

Hayles, N. K. (1999). *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics.* Chicago: University Chicago Press.

Hayles, K. (2005). *My Mother Was a Computer.* Chicago: University Of Chicago Press.

Haythornthwaite, C. (2005). Social networks and Internet connectivity effects. *Information, Community & Society*, 8(2), pp.125-147.

Hatch, M. (2013). *The Maker Movement Manifesto: Rules for Innovation in the New World of Crafters, Hackers, and Tinkerers.* McGraw-Hill Professional.

Healey, P. G., White, G., Eshghi, A., Reeves, A. J. and Light, A. (2008). Communication spaces. *Computer Supported Cooperative Work (CSCW)*, 17(2-3), pp. 169-193.

Heath, C., and Luff. P. (2000). *Technology in Action.* Cambridge: Cambridge University Press.

Heidegger, M. (1975). *Poetry, Language, Thought*. NY: Harper & Row.

Held, D., McGrew, A., Goldblatt, D., and Perraton, J. (1999). *Global Transformations*. Cambridge: Polity Press.

Henry, C. (1993). New technology, more technology: NREN metaphors. *Wilson Library Bulletin*, pp. 30-32.

Herring, S. C. (2000). Gender Differences in CMC: Findings and Implications. *CPSR Newsletter*, *18*(1), pp. 1–8.

Higgins, C. (2010). Labour, Work, and Action: Arendt’s Phenomenology of Practical Life. *Philosophy of Education*, 44(2).

Hindi, R. (2015). How Artificial Intelligence Will Make Technology Disappear. Retrieved 1 April 2017 from https://medium.com/snips-ai/how-artificial-intelligence-will-make-technology-disappear-503cd88e1e6a

Hine, C. (2000). *Virtual Ethnography.* London: SAGE.

Hintz, A. (2015). Book reviews. *Journal for Alternative and Community Media*.

Hintz, A. (2016). Restricting digital sites of dissent: commercial social media and free expression. *Critical Discourse Studies*, 13(3), pp. 325-340.

Hockey, J. (2002). Interviews as ethnography? Disembodied social interaction in Britain. In: Rapport N (Ed.), British Subjects: *An Anthropology of Britain.* Oxford: Berg.

Hoey, B. (2008). Ethnographic practice: What is ethnography? Retrieved on 12 December 2009 from www.brianhoey. com/General%20Site/general_defn-ethnography.htm

Holstein, J. A., and Gubrium, J. F. (1995). *The Active Interview*. London: SAGE.

Hopper, A. (1999). Sentient Computing. The Clifford Paterson Lecture, Phil. Trans. R. Soc. London, Retrieved 1 April 2018 from http://www.uk.research.att.com/pub/docs/att/tr.1999.12.pdf

Hopper, A. (1999). The Clifford Paterson lecture: sentient computing. *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences*, 2000, *358*(1773), pp. 2349-2358.

Howard, P. N. (2002). Network Ethnography and the Hypermedia Organization: New Media, New Organizations, New Methods. *New Media & Society*, 4(4), pp. 550–574.

Howe, J. (2006). The rise of crowdsourcing. *The Wired*, 14(06). Retrieved on 16 February 2009 from http://www.wired.com/wired/archive/14.06/crowds.html

Hunt, S. A., Benford, R. D., and Snow, D. A. (1994). Identity fields: Framing processes and the social construction of movement identities. *New social movements: From ideology to identity*, pp. 185-208.

Husserl, E. (1970). *The Crisis of European Sciences and Transendental Phenomenology: An Introduction to Phenomenological Philosophy*. Evanson Illinois: Northwestern University Press.

Hymes, D. (1972). Models of the interaction of language and social life. In Gumperz, J. J., and Hymes, D. (Eds.) *Directions in Sociolinguistics: The Ethnography of Communication*, New York: Holt, Rinehart, Winston, pp. 35– 71.

Hymes, D. (1996). *Ethnography, Linguistics, Narrative Inequality*. London: Taylor & Francis.

Iliadis, A., and Russo, F. (2016). Critical data studies: An introduction. *Big Data and Society*, pp. 1-7.

Ingarden, R. (1973). *The Cognition of the Literary Work of Art*, (trans. by Crowley, R.A., and Olson, K.R.), Evanston Illinois: Northwestern University Press.

IoT Bussness News, (2012). Internet of Things in the Top 10 Technology Trends for 2013 according to Icreon Tech. *IoT Business News*. Retrieved on 1 April 2017 from http://tinyurl.com/d4s9q49

Irwin, A. (1995). *Citizen Science: A study of People, Expertise and Sustainable Development*. London: Routledge.

James, L. (2018). Oaths, pledges and manifestos: a master list of ethical tech values. Medium. Retrieved on 1 November 2018 from https://medium.com/doteveryone/oaths-pledges-and-manifestos-a-master-list-of-ethical-tech-values-26e2672e161c

Jamet, D. L., and Moulin–Lyon, J. (2010). What do Internet metaphors reveal about the perception of the Internet. *Metaphorik. de*, 18(2), pp. 17-32.

Jesiek, B. K. (2003). Democratizing software: Open source, the hacker ethic, and beyond. *First Monday*, 8(10).

Jewson, N. (2007). Cultivating network analysis: rethinking the concept of "community" within communities of practice. In Hughes, J., Jewson, N., and Unwin, L. (Eds.) *Communities of practice: critical perspectives.* London/NY: Routledge.

Johnson, R., and Cureton, A. (2017). *Kant's Moral Philosophy.* The Stanford Encyclopedia of Philosophy.

Kampa, M., and Castanas, E. (2008). Human health effects of air pollution. *Science Direct,* 151, pp. 362–367.

Kant, I. (orig.1781, 2017). *The Critique of Pure Reason.* GB: CreateSpace Amazon.

Kaplan, A., and Ross, K. (1987). Introduction to a special issue on the everyday, *Yale French Studies* 73(9), p. 3.

Kar, S. (2012). Gartner: Top 10 Key Technology Trends for 2013. *Cloud Times*. Retrieved on 1 April 2017 from http://cloudtimes.org/2012/11/06/gartner-top-10-key-technology-trends-for-2013/

Kelty, C. M. (2008). *Two Bits: The Cultural Significance of free Software*. Durham and London: Duke University Press.

Kera, D., and Graham, C. (2010). Collective sensor networks and future communities: designing interaction across multiple scales. In *Proceedings of the 22nd Conference of the Computer-Human Interaction Special Interest Group of Australia on Computer-Human Interaction*, ACM, pp. 396-399.

Kingsly, S. R., and Kaviyarasi, G. (2014). A survey of fault node identification. *Development Research*, 4, pp. 898–901.

Kitchin, R., and Dodge, M. (2011). *Code/Space.* Cambridge MA/London: The MIT Press.

Kitchin, R. (2014). Big Data, new epistemologies and paradigm shifts. *Big Data and Society*, (April-June), pp. 1–12.

Kleemann, F., and Voß, G. G. (2008). Un(der)paid Innovators: The Commercial Utilization of Consumer Work through Crowdsourcing. *Science, Technology and Innovation Studies*, 4(1), pp. 5–26.

Koenig, T. (2004). On frames and framing. In *IAMCR Annual Meeting, Porto Alegre, Brazil, July*.

Kondratieff, N. (1984) (orig 1925). *The Long Wave Cycle.* Boston, MA: Richardson & Snyder.

Koomey, J. G. (2011). Growth In Data Center Electricity Use 2005 To 2010. *A report by Analytics Press, completed at the request of The New York Times.* Retrieved on 1 May 2017 from http://www.analyticspress.com/datacenters.html

Kortuem, G., Kawsar, F., Sundramoorthy, V., and Fitton, D. (2010). Smart objects as building blocks for the internet of things. *IEEE Internet Computing,* 14(1), pp. 44–51.

Kostakis, V., and Bauwens, M. (2014). Network Society and Future Scenarios for a Collaborative Economy - Preface. In *Network Society and Future Scenarios for a Collaborative Economy,* pp. 3-4.

Kostakis, V., and Bauwens, M. (2013). Network Society and Future Scenarios for a Collaborative Economy. Originally published by *P2P Foundation.* Retrieved on 1 May 2017 from http://www.resilience.org/stories/2013-10-31/network-society-and-future-scenarios-for-a-collaborative-economy/

Kotin, P., and Falk, H. L. (1964). Atmosphere Pollutants. *Annual Review of Medicine*, 15(1), pp. 233–254.

Krajewski, M. (2013). Paper as Passion: Niklas Luhmann and His Card Index. In Gitelman, L (Ed.), "*Raw Data" Is an Oxymoron,* pp. 103-120.

Kranenburg, R. (2008). *The Internet of Things: A critique of ambient technology and all-seeing network of RFID.* Institute of Network Cultures.

Kranz, M., Holleis, P., and Schmidt, A. (2010). Embedded Interaction: Interacting with the Internet of Things, *IEEE Internet Computing Internet of Things Track*, pp. 46–53.

Kranz, M., Roalter, L., and Michahelles, F. (2010). Things that twitter: social networks and the internet of things. In *What can the Internet of Things do for the Citizen (CIoT) Workshop at The Eighth International Conference on Pervasive Computing (Pervasive 2010),* pp. 1-10.

Kravets, D. (2010). Feds: Privacy Does Not Exist in 'Public Places'. *Wired*. Retrieved on 10 Sept 2017 from https://www.wired.com/2010/09/public-privacy/

Kravets, D. (2010). ACLU Study Highlights U.S. Surveillance Society. *Wired*. Retrieved on 10 Sept 2017 from https://www.wired.com/2010/06/aclu-surveillance/

Konomi, S. and Roussos, G. (2006). Ubiquitous computing in the real world: lessons learnt from large scale RFID deployments. Personal and Ubiquitous Computing, 11, (7), pp 507–521.

Krishnamurthy, S. (2002). Cave or Community? An Empirical Examination of 100 Mature Open Source Projects. *First Monday*, 7(6).

Kuhn, T. S. (1970). *The Structure of Scientific Revolutions.* The University of Chicago, 2nd Edition.

Kullenberg, C., and Kasperowski, D. (2016). What Is Citizen Science ? - A Scientometric. *PLOS One*, pp. 1-16.

Kusko, B. (1994). *Fuzzy Thinking: The New Science of Fuzzy Logic.* Flamingo.

Kuznetsov, S. (2010). Rise of the expert amateur: DIY projects, communities, and cultures. In *Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries,* pp. 295–304.

Lakoff, G. (1992). The Contemporary Theory of Metaphor. In Ortony, A. (Ed.), *Metaphor and Thought*. 2nd edition, Cambridge: Cambridge University Press.

Lakoff, G., and Johnson, M. (1980). *Metaphors we live by.* Chicago: University of Chicago Press.

Lakoff, G. (2010). Why it matters how we frame the environment. *Environmental Communication*, 4(1), pp. 70-81.

Lakoff, G., and Turner, M. (1989). *More than cool reason: A field guide to poetic metaphor*. Chicago: University of Chicago Press.

Lane, T. (2005). The "Only" Coke Machine on the Internet. Retrieved on 17 March 2017 from http://www.cs.cmu.edu/%7Ecoke/history_long.txt

Landwerhr, D. (2014). *Hacking - Edition Digital Culture 2*. Basel: Christoph Merian Verlag.

Landt, J. (2005). The history of RFID, IEEE Potentials 24 (4), pp. 8–11.

Latour, B. (1987). *Science in Action.* Cambridge, MA: Harvard University Press.

Latour, B. (1988). *The Pasteurization of France*. Cambridge, MA: Harvard University Press.

Latour, B. (1993). *We Have Never Been Modern.* London: Harvester Wheatsheaf.

Latour, B. (1996). *Aramis or the Love of Technology*. Cambridge, MA: Harvard University Press.

Latour, B. (1996). On actor-network theory: A few clarifications plus more than a few complications. In *Soziale Welt, V*ol. 47, pp. 369-381.

Latour, B. (1999). On recalling ANT. In Law, J., and Hassard, J. (Eds.) *Actor Network and After*. Oxford: Blackwell, p. 15.

Latour, B. (2007). *Reassembling the Social.* New York: Oxford University Press.

Latour, B. (2013). Facing Gaia: A new enquiry into Natural Religion. Gifford Lecture series video, Retrieved on September 10, 2014 from https://www.youtube.com/watch?v=MC3E6vdQEzk

Lave, J. (1988). *Cognition in Practice: Mind, Mathematics and Culture in Everyday Life.* Cambridge: Cambridge University Press.

Lave, J., and Wenger, E. (1991). *Situated Learning.* Cambridge USA: Cambridge University Press. First published in 1990 as Institute for Research on Learning report 90-0013.

Law, J. (1991). Introduction: monsters, machines and sociotechnical relations. In Law, J. (Ed.), *A Sociology of Monsters,* London: Routledge, p. 1.

Law, J. (1992). Notes on the theory of the actor network: ordering, strategy and heterogeneity. *Systems Practice* 5, pp. 379- 393.

Lee-Won, R. J., Herzog, L., and Park, S. G. (2015). Hooked on Facebook: the role of social anxiety and need for social assurance in problematic use of Facebook. *Cyberpsychology, Behaviour, and Social Networking*, 18(10), pp. 567-574.

Lefebvre, H. (1995). *Writings on Cities.* UK: Wiley-Blackwell.

Lefebvre, H. (1991). *The Production of Space.* Trans. by Donald Nicholson-Smith. UK: Blackwell.

Lefebvre, H. (2004). *Rhythmanalysis: Space, time and everyday life.* Trans. By Stuart Elden, Gerald Moore. New York: Continuum.

Lefebvre, H. (2009) (orig.1968). *Dialectical materialism.* Minneapolis: University of Minnesota Press, 1st edition.

Leonard, A. (1999). Open-source journalism. Salon.com. Retrieved on 1 April 2017 from http://www.salon.com/1999/10/08/geek_journalism/

Lessig, L. (1999). *Code and other laws of cyberspace.* New York: Basic Books.

Lessig, L. (2001). *The future of ideas: The Fate of the Commons in Connected World*. New York:

Random House.

Levin, S., and Wong, J.C. (2018). Self-driving Uber kills Arizona woman in first fatal crash involving pedestrian. The Guardian. Retrieved on 1 November 2018 from https://www.theguardian.com/technology/2018/mar/19/uber-self-driving-car-kills-woman-arizona-tempe

Li, S., Xu, L. Da, and Zhao, S. (2015). The internet of things: a survey. *InfoSys Front*, pp. 243–259.

Lidskog, R., and Sundqvist, G. (2011). Transboundary Air Pollution Policy in Transition. In Lidskog, G.S.R. (Ed.), *Governing the Air. The Dynamics of Science, Policy, and Citizen Interaction.* Cambridge MA, London: MIT Press, pp. 1–35.

Lievrouw, L. A. (2001). New media and the 'pluralization of life-worlds': A role for information in social differentiation. *New Media and Society*, 3(1), pp. 7–28.

Light, A. and Miskelly, C. (2008). Brokering between Heads and Hearts: an analysis of designing for social change. *Proc. DRS'08*.

Light, A., and Miskelly, C. (2015). Sharing economy vs sharing cultures? Designing for social , economic and environmental good social, economic and environmental good. *Interaction Design and Architecture(s)*, pp. 49–62.

Lovink, G. (2011). *Networks Without a Cause: A critique of Social Media*. Cambridge: Polity.

Lukianova, N., and Fell, E. (2014). Internet of things as a symbolic resource of power. In *Proceedings - Social and Behavioural Sciences*, *166* (2015), pp. 521 – 525.

Lueth, K. L. (2015). The 10 most popular Internet of Things applications right now. Retrieved 1 April 2017 from https://iot-analytics.com/10-internet-of-things-applications/

Lundvall, B., and Johnson, B. (1994). The Learning Economy. *Journal of Industry Studies,* 1, pp. 23-42.

Ma, H. (2011). Internet of Things: Objectives and Scientific Challenges. *Journal of Computer Science and Technology*, 26, pp. 919–924.

Mackenzie, A. (2003). Transduction: Invention. Innovation and Collective Life. Unpublished manuscript. Retrieved on 1 April 2017 from http://www.lancaster.ac.uk/staff/mackenza/papers/transduction.pdf

Mackenzie, A. (2006). *Cutting code: Software and sociality.* New York: Peter Lang.

Maglio, P. P., Matlock, T., Campbell, C. S., Zhai, S., and Smith, B. A. (2001). Gaze and Speech in Attentive User Interfaces. *In Lecture Notes in Computer Science,* 1948, pp. 1-7.

Maglio, P. P., and Matlock, T. (1998). Metaphors we surf the web by. In *Workshop on personalized and social navigation in information space*.

Manovich, L. (2000). *The language of new media*. Cambridge, MA: MIT Press.

Manovich, L. (2004). Info-Aesthetics book proposal. Retrieved on 3 April 2016 from http://manovich.net/index.php/projects/info-aesthetics

Manovich, L. (2008). Software takes command. Retrieved on 20 November 2009 from http://lab.softwarestudies.com!2008/11/softbook.html

Mansell, J and Matheson, B. (2016). Data Commons Blueprint. N*ew Zealand Data Futures Partnership.* Retrieved on 1 November 2018 from http://datacommons.org.nz/

Marcus, G., and Fischer, M.M.J. (1986). *Anthropology as cultural critique: An experimental moment in the human sciences.* Chicago: University of Chicago Press.

Marcus, G. (1998a). Ethnography in/of the world system: The emergence of multi-sited ethnography. In Marcus, G. (Ed.), *Ethnography through thick and thin*, pp. 79–104. Princeton, NJ: Princeton University Press.

Marcus, G. (1998b). Imagining the whole: Ethnography's contemporary efforts to situate itself. In Marcus, G. (Ed.), *Ethnography through thick and thin*, pp. 33–56. Princeton, NJ: Princeton University Press.

Marenko, B. (Ed.) (2005). *DIY Survival.* C6 and ACE.

Marx, K. (1990). *Capital Volume I.* England: Penguin Classics.

Marx, K. (1859). *A Contribution to the Critique of Political Economy.* Progress Publishers, Moscow (1977). Retrieved on 2 April 2017 from https://www.marxists.org/archive/marx/works/1859/critique-pol-economy/preface.htm

Mashhadi, A., Kawsar, F., and Acer, U. G. (2014, March). Human data interaction in IoT: The ownership aspect. In *Internet of Things (WF-IoT), 2014 IEEE World Forum,* pp. 159-162.

Massey, D. (1991). A Global Sense of Place. *Marxism Today.* 38.

Massey, D. (1992). Politics and space/time. *New Left Review*, (196), p.65.

Massey, D. (1994). *Space, place and gender.* London: Methuen.

Massey, D. (2005). *For Space.* London: Sage.

Mattern, F., and Ferscha., A. (Eds.) (2004). *Pervasive Computing.* Switzerland: Springer.

Mazzarella, W. (2004). Culture, globalization, mediation. *Annual Review of Anthropology*, 33, pp. 345–367.

McCann, J. (2013). Data is the most valuable commodity of Earth. Retrieved 1 April 2016 from: https://web.archive.org/web/20160316061801/http://subprint.com/blog/data-is-the-most-valuable-commodity-on-earth

McCue, T. J. (2012). 14 billion software as a service industry growth influences maker companies. *Forbes*. Retrieved on 16 June 2015 from http://www.forbes.com

McCahill, L. (2015). 11 ridiculously easy ways to thingify your thoughts and just f*****g do it. *Medium*. Retrieved September 2017 from: https://medium.com/the-happy-startup-school/11-ridiculously-easy-ways-to-thingify-your-thoughts-and-just-f-g-do-it-bc94d94201cd

Mcniff, J. (2014). *Writing and Doing Action Research*. London: Sage Publications Ltd; 1st Edition

Mcniff, J., and Whitehead, A. (2011). *All You Need to Know About Action Research Publications.* 2nd edition. London: Sage.

Medosch, A. (2015). The Incomplete Paradigm Shift. Retrieved on 1 April 2017 from https://web.archive.org/web/20160320135801/http://thenextlayer.org/node/1324#footnoteref2_lc08e0q

Meetham, A. R. (1954). Natural removal of atmospheric pollution during fog. *Quarterly Journal of the Royal Meteorological Society*, 80(343), pp. 96-99.

Mendel, J. M., Fellow, L., Wu, D., and Member, S. (2008). Perceptual Reasoning for Perceptual Computing. *IEEE Transactions On Fuzzy Systems,* 16(6), pp. 1550–1564.

Merleau-Ponty, M. (1962). *Phenomenology of perception.* Trans. By Colin Smith. London: Routledge & Kegan Paul.

Merleau-Ponty, M. (2004). *The Visible and the Invisible: The Intertwining—The Chiasm*. (Ed. Thomas Baldwin), Routledge.

Merleau-Ponty, M. (2008). *Phenomenology of Perception*. London and New York, Routledge.

Michahelles, F. (Ed.) (2008). Producing Standards for the Internet of Things. *First International Conference on The Internet of Things.* Retrieved on 1 April 2017 from https://www.ncbi.nlm.nih.gov/pubmed/22679075

Miller, D. (2013). Not Getting the Internet. Retrieved on 1 April 2017 from https://www.fairobserver.com/culture/not-getting-internet/

Miller, H. J. (2010). The Data Avalanche Is Here. Shouldn't We Be Digging? *Journal Of Regional Science*, 50(1), pp. 181–201.

Miller, K. A., Siscovick, D. S., Sheppard, L., Shepherd, K., Sullivan, J. H., Anderson, G. L., and Kaufman, J. D. (2007). Long-Term Exposure to Air Pollution and Incidence of Cardiovascular Events in Women. *The New England Journal of Medicine*, 356(5), pp. 447–458.

Miller, P., Styles, R., and Heath, T. (2008). Open Data Commons, a License for Open Data. *LDOW, 369*.

Mineraud, J., Mazhelis, O., Su, X., and Tarkoma, S. (2016). A gap analysis of Internet-of-Things platforms. *Computer Communications*, *89*, 5-16.

Mitton, N., and Simplot-Ryl, D. (2011). From the Internet of things to the Internet of the physical world. *Comptes Rendus Physique,* 12(7), pp. 669–674.

Mollick, E. (2013). The dynamics of crowdfunding: Determinants of success and failures. *Draft for Journal of Business Venturing.*

Mollick, E. (2014). The dynamics of crowdfunding: An exploratory study. *Journal of business venturing*, 29(1), pp. 1-16.

Moore, J. (2015). *Capitalism in the Web of Life.* NY: Verso.

Moore, P. V. (2018). *The Quantified Self in Precarity: Work, Technology and What Counts*. London /NY: Routledge.

Morduch, J., Pitt, M., and Robinson, M. (1999). The Microfinance Promise. *Journal of Economic Literature*, *XXXVII*, pp. 1569–1614.

Mortimer, R. (2011). Why we believe that data is the new oil… . *Marketing Week*. Retrieved on 1 April 2017 from https://www.marketingweek.com/2011/12/07/why-we-believe-that-data-is-the-new-oil/

Nafus, D., and Sherman, J. (2014). Big data, big questions| this one does not go up to 11: the quantified self movement as an alternative big data practice. *International journal of communication*, 8, p. 11.

Nafus, D., and Sherman, J. (2014). This One Does Not Go Up to 11: The Quantified Self Movement as an Alternative Big Data Practice. *International Journal of Communication,* 8, pp. 1784–1794.

Ndasauka, Y., Hou, J., Wang, Y., Yang, L., et al. (2016). Excessive use of Twitter among college students in the UK: Validation of the Microblog Excessive Use Scale and relationship to social interaction and loneliness. *Computers in Human Behaviour,* 55, pp. 963-971.

Newman, D. (2018). The top 8 IoT trends for 2018. The Forbs. Retrieved on 1 November 2018 from https://www.forbes.com/sites/danielnewman/2017/12/19/the-top-8-iot-trends-for-2018/#1f2fa24067f7

Negroponte, N. (1996). *Being digital*. New York: Vintage Books.

Ning, H., and Wang, Z. (2011). Future Internet of Things Architecture: *IEEE Communications Letters,* 15(4), pp. 461–463.

Noble, J. (2009). Pachube, Patching the planet: Interview with Usman Haque. Retrieve on 1 April 2017 from http://www.ugotrade.com/2009/01/28/pachube-patching-the-planet-interview-with-usman-haque/

Nold, C. (2009). *Emotional Cartography - Technologies of the Self.* Retrieved on April 1 2017 form http://emotionalcartography.net/EmotionalCartographyLow.pdf

Nyberg, F., Gustavsson, P., Ja, L., Bellander, T., and Berglind, N. (2000). Urban Air Pollution and Lung Cancer in Stockholm. *Epidemiology, Cambridge, Mass.* 11(5), pp. 487–495.

O’Connor, K. (2003). Communicative practice, cultural production and situated learning: Constructing and contesting identities of expertise in a heterogeneous learning context. In Wortham & Rymes (Eds), pp. 61-92.

Ockman, S., and DiBona, C. (1999). *Open Sources: Voices from the Open Source Revolution.* O'Reilly Media.

O'Neil, C. (2017). *Weapons of Math Destruction*. NY: Penguin.

O’Reilly, K. (2009). *Key Concepts in Ethnography.* Los Angeles, CA: SAGE.

O'Reilly, T. (2004). Open Source Paradigm Shift. Retrieved on 1 April 2017 from http://archive.oreilly.com/pub/a/oreilly/tim/articles/paradigmshift_0504.html

Orlikowski, W. J., and Iacono, C. S. (2000). The Truth Is Not Out There: An Enacted View of the Digital Economy. In Brynjolfsson, E.,and Kahin, B. (Eds.) *Understanding the Digital Economy: Data, Tools, and Research*, Boston: MIT Press, pp. 352-380.

Orlikowski, W., and Scott, S. (2008). Sociomateriality: Challenging the Separation of Technology, Work and Organization. *The Academy of Management Annals,* pp. 433-474.

O'Rourke, D., and Macey, G. P. (2003). Community environmental policing: Assessing new strategies of public participation in environmental regulation. *Journal of Policy Analysis and Management,* 22(3), pp. 383–414.

Ostrom, E. (2012). *The Future of the Commons.* GB: The Institute of Economic Affairs.

Ottinger, G. (2010). Buckets of resistance: Standards and the effectiveness of citizen science. *Science, Technology & Human,* 35(2), pp. 244–270.

Owen, G and Ward, J. (2006). Smart Meters: Commercial, Policy and Regulatory Drivers. Sustainability First. Retrieved on 1 November 2018 from https://www.ofgem.gov.uk/sites/default/files/docs/2006/03/13383-sustainability_first_response__0.pdf

Palladino, V. (2018). Amazon knows about the bug and is working to fix it. Retrieved on 2 December 2018 https://arstechnica.com/gadgets/2018/03/unprompted-creepy-laughing-from-alexa-is-freaking-out-echo-users/

Palmquist, R. A. (1996). *The Search for an Internet Metaphor: A Comparison of Literatures.* ASIS.

Park, H., Lee, B., Ha, E., Lee, J., Kim, H., and Hong, Y. (2002). Association of Air Pollution With School Absenteeism Due to Illness. *Archives of Paediatrics & Adolescent Medicine,* 156(12), pp. 1235–1239.

Pearce, J. M. (2013). *Open-Source Lab: How to Build Your Own Hardware and Reduce Research Costs.* Elsevier.

Prensky, M. (2001). Digital Natives, Digital Immigrants. *On the Horizon,* 9(5), pp. 1-6.

Perera, C., Member, S., Zaslavsky, A., Christen, P., and Georgakopoulos, D. (2014). Context Aware Computing for The Internet of Things: A Survey. *IEEE Communications Surveys & Tutorials*, 16(1), pp. 414–454.

Perez, C. (2002). *Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages.* Cheltenham, UK; Northampton, MA, USA: Edward Elgar Publishing.

Perez, C. (2009). Technological revolutions and techno-economic paradigms. *Cambridge journal of economics,* p. 51.

Peters, A., Dockery, D. W., Heinrich, J., and Wichmann, H. E. (1997). Medication Use Modifies the Health Effects of Particulate Sulfate Air Pollution in Children with Asthma. *Environmental Health Perspectives*, 105(4), pp. 430–435.

Pickering, A. (1993). The mangle of practice: Agency and emergence in the sociology of science. *American journal of sociology*, 99*(*3), pp. 559-589.

Pickering, A. (1995). *The mangle of practice: Time agency and science.* Chicago: University of Chicago Press.

Pitkin, H. F. (1981). On Relating Private and Public. *Political Theory*, 9(3), pp. 327–352.

Phillips, N., and Hardy, C. (2002). Discourse Analysis: Investigating Processes of Social Construction. *Qualitative research methods series, 50*.

Poetz, M. K., and Schreier, M. (2012). The value of crowdsourcing: Can users really compete with professionals in generating new product ideas? *Journal of Product Innovation Management*, 29, pp. 245-256.

Pope, C. A. III, Bates, D., and Raizenne, E. (1995). Health Effects of Particulate Air Pollution: Time for Reassessment? *Environmental Health Perspectives,* 103(5), pp. 472–480.

Procomuns (2016). Summary: procomuns statement and policies for Commons Collaborative Economies at European level.

Punie, Y., Maghiros, I., and Delaitre, S. (2006). Dark Scenarios as a Constructive Tool For Future - Oriented Technology analysis: Safeguards In A World Of Ambient Intelligence (Swami). *2nd International Seville Seminar on Future-Oriented Technology Analysis,* pp. 1–16.

Qiu, C. (2013). Issues in Crowdfunding: theoretical and empirical investigation on Kickstarter. *SSRN*. Retrieved 1 April 2017 from http://ssrn.com/abstract=2345872

Rand, D. (2013). Air Quality Egg for Schools (AQEfS). Retrieved on 3 March 2017 from http://ec.europa.eu/environment/archives/greenweek2013/sites/default/files/content/presentations/9-2_rand.pdf

Ramos, C., Augusto, J. C., and Shapiro, D. (2008). Ambient Intelligence - the Next Step for Artificial Intelligence. *Intelligent Systems, IEEE*, 23(2), pp. 15-18.

Rampton, B., Tusting, K., Maybin, J., Barwell, R., Creese, A., and Lytra, V. (2004). UK Linguistic ethnography. A discussion paper, pp. 1–24.

Ray, S., Jin, Y., and Raychowdhury, A. (2016). The Changing Computing Paradigm With Internet of Things: A Tutorial Introduction. *IEEE Design &Test*, pp. 76–96.

Raymond, E. S. (1999). *The Cathedral and the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary.* O'Reilly Media.

Reason, P., and Brandbury, H. (Eds.) (2013). *The Sage Handbook of Action Research: Participative Inquiry And Practice. 2 edition.* GB: Sage Publications.

Ribes, D., and Jackson, S. J. (2013). Data Bite Man: The Work of Sustaining a Long-Term Study. In Gitelman, L. (Ed.), "*Raw Data" Is an Oxymoron,* pp. 147 – 166.

Riesch, H., and Potter, C. (2014). Citizen Science as Seen by Scientists: Methodological, Epistemological and Ethical Dimensions. *Public Understanding of Science,* 23(1), pp. 107–120.

Rifkin, J. (2014). *The Zero Marginal Cost Society; The Internet of Things, The Collaborative Commons, and the Eclipse of Capitalism.* USA: Palgrave.

Roberts, J. (2006). Limits to communities of practice. *Journal of Management Studies*, 43(3), pp. 623–639.

Robinson, M. (2001). *The Microfinance Revolution: Sustainable finance for the poor*. Washington, DC: The World Bank.

Rogers, K. (2017). The FCC Just Killed Net Neutrality - Now What? *Motherboard.* Retrieved on 12 December 2017 from https://motherboard.vice.com/en_us/article/qvz3vd/the-fcc-just-killed-net-neutralitynow-what

Rohe, B. (2017). #Data – The New #Oil - and who is going to own it?. Retrieved 1 April 2017s from https://www.huffingtonpost.com/entry/data-the-new-oil-and-who-is-going-to-own-it_us_58d06e72e4b0537abd957410

Rorty, R. (2000). *Philosophy and Social Hope.* Harmondsworth: Penguin.

Rosenberg, D. (2013). Data before the Fact. In Gitelman, L. (Ed.), "*Raw Data" Is an Oxymoron.* pp. 15-40.

Rossman, J., Shaw, G., Shouse, T., and Anderson, B. (2016) *The Amazon Way on IoT: 10 Principles for Every Leader from the World's Leading Internet of Things Strategies: Volume 2*. USA: John E. Rossman.

Rothman, J., Erlich, J. L., and Tropman, J. E. (2001). Strategies of Community Intervention: Macro Practice. USA: Wadsworth Publishing.

Ruparelia, N. B. (2016). *Cloud Computing.* Cambridge MA/ London: MIT Press.

Rushkoff, D. (2019). *Team Human*. NY: W. W. Norton & Company.

Ryle, G. (2009). *Critical Essays: Collected Papers Volume 1.* USA: Routledge.

Sachs, K., Petrov, I., and Guerrero, P. (Eds.) (2010). *From Active Data Management to Event-Based Systems and More*. Berlin/ Heidelberg/ New York: Springer.

San Miguel, M., Johnson, J. H., Kertesz, J., Kaski, K., Díaz-Guilera, A., MacKay, R. S., and Helbing,

D. (2012). Challenges in complex systems science. *The European Physical Journal Special Topics*, 214(1), pp. 245–271.

Santucci, G. (2010). The Internet of Things: Between the Revolution of the Internet and the Metamorphosis of Objects. In *Vision and Challenges for Realising the Internet of Things*, published by CERP-IOT, European Commission.

Sarma, S. (2004). Integrating RFID. *ACM Queue*. 2 (7), pp. 50-57.

Schechner, R. (2013). *Performance Studies: An Introduction*. Routledge London.

Schell, L. M., and Denham, M. (2003). Environmental Pollution in Urban Environments and human Biology. *Annual Review of Anthropology,* 32(1), pp. 111–134.

Schmidt, A. (2003). Ubiquitous Computing - Computing in Context. *Environments, Citeseer.* Retrieved on 2 April 2017 from http://eprints.lancs.ac.uk/12221/

Schroeder, R. (2007). *Rethinking Science, Technology, and Social Change.* Stanford, CA: Stanford University Press.

Schumpeter, J. A. (2011). *Capitalism, Socialism and Democracy.* USA: Martino Publishing.

Schwartz, J., Slater, D., Larson, T. V., Pierson, W. E., and Koenig, J. Q. (1993). Particulate air pollution and hospital emergency room visits for asthma in Seattle. *The American Review of Respiratory Disease,* 147(4), pp. 826–831.

Schwienbacher, A., and Larralde, B. (2010). Crowdfunding of small entrepreneurial ventures. *SSRN Electronic Journal.*

Science Communication Unit, University of the West of England, Bristol (2013). Science for Environment Policy In-depth Report: Environmental Citizen Science. *Report produced for the European Commission DG Environment.*

Seaton, A., MacNee, W., Donaldson, K., and Godden, D. (1995). Particulate air pollution and acute health effects. *Lancet*, 345(8943), pp. 176–178.

Sennett, R. (2008). *The Craftsman.* UK: Penguin Books.

Sessions, L. F. (2010). How Offline Gatherings Affect Online Communities. *Information, Communication & Society*, 13(3), pp. 375–395.

Shenker, J. (2017). It's really shocking': UK cities refusing to reveal extent of pseudo-public space. *The Guardian.* Retrieved on 10 September 2017 from https://www.theguardian.com/cities/2017/sep/26/its-really-shocking-uk-cities-refusing-to-reveal-extent-of-pseudo-public-space

Sheth, A., Anantharam, P., & Henson, C. (2016). Semantic, cognitive, and perceptual computing: Paradigms that shape human experience. *Computer*, *49*(3), 64-72.

Shuen, A. (2008). *Web 2.0: A Strategy Guide: Business thinking and strategies behind successful Web 2.0 implementations.* O'Reilly Media.

Silverstone, R. (1990). Television and everyday life: towards an anthropology of the television audience. *Public communication: the new imperatives,* pp. 173-189.

Silverstone, R., Hirsch, E., and Morley, D. (1991). Listening to a long conversation: An ethnographic approach to the study of information and communication technologies in the home. *Cultural Studies*, 5(2), pp. 204–227.

Simms, A., and Potts, R. (2012). *The New Materialism: How our relationship with the material world can change for the better.* Bread Print Roses.

Slobogin, C. (2002). Public Privacy: Camera Surveillance of Public Places And The Right to Anonymity. *Mississippi Law Journal, 72*.

Smite, R, Medosch, A. and Smits, R. (2011). Network and Sustainability. *Acoustic Space, No. 10*. Riga, Liepaja: RIXC, MPLab.

Smith, K. R., Bruce, N., Balakrishnan, K., Adair-Rohani, H., Balmes, J., Chafe, Z., and Rehfuess, E. (2014). Millions dead: How do we know and what does it mean? Methods used in the comparative risk assessment of household air pollution. *Annual Review of Public Health,* 35(1), pp. 185–206.

Snow, D. A., and Benford, R. D. (1992). Master frames and cycles of protest. *Frontiers in social movement theory*, pp. 133-155.

Söderström, O., Paasche, T., and Klauser, F. (2014). Smart cities as corporate storytelling. *City* 18 (3), pp. 307-320.

Solomon, G. M., Campbell, T. R., Feuer, G. R., Masters, J., Samkian, A., and Paul, K. A. (2001). No Breathing in The Aisles: Diesel Exhaust Inside School Buses. *Natural Resources Defence Council Coalition for Clean Air.*

deSouza e Silva, A., and Sutko, D. M. (2009). Digital Cityscapes: Merging Digital and Urban Playspaces. USA: Peter Lang Publishing Inc.

Souder, W. E., and Moenaert, K. D. (1992). Integrating marketing and R&D project personnel within innovation projects: an information uncertainty model. *Journal of Management Studies*, 29(4), pp. 485-512.

Spengler, J., Samet, J., and McCarthy, J. F. (2000). *Indoor Air Quality Handbook.* New York: McGraw Hill Book Co.

Spohrer, J., and Stein, M. (2000). User experience in the pervasive computing age. *IEEE Multimedia*, 7(1), pp. 12-17.

Srnicek, N. (2017). *Platform Capitalism.* Cambridge: Polity.

Stahl, T. (2016). Indiscriminate mass surveillance and the public sphere. *Ethics and Information Technology*, *18*(1), pp. 33–39.

Stafford-Fraser, Q. (1995). The Trojan Room Coffee Pot. Retrieved on 21 October 2017 from http://www.cl.cam.ac.uk/coffee/qsf/coffee.html

Stake, R. (2008). Qualitative Case Studies. In N. K. Denzin, N.K. and Lincoln, Y. S. (Eds.), *Strategies of qualitative inquiry (3rd Ed.)* Los Angeles: Sage Publications. pp. 119-150.

Stalder, F. (2006). *Flows and Places. In Castells, M. The Theory of the Network Society*. Polity Press. pp. 141–166.

Staniforth, S. (2013). *Historical perspectives on preventive conservation* (Vol. 6). Los Angeles: Getty Publications.

Stankovic, J. A. (2014). Research Directions for the Internet of Things. *IEEE*, pp. 1–7.

Statham, P., and Mynott, E. (2002). The Dilemma of Anti-Racist and Pro-Migrant Mobilisation in Britain: Visibility or Political Power?. *Paper for the Joint Sessions of the ECPR Immigration Politics: Between Centre and Periphery, National States and the EU*, Turin, Italy, pp. 22-27.

Sterling, B. (2005). *Shaping Things.* Mediawork Pamphlets, Cambridge, Mass: The MIT Press.

Stern, A. C., and Professor, E. (1982). History of Air Pollution Legislation in the United States. *Journal of the Air Pollution Control Association,* 32(1), pp. 44–61.

Strathern, M. (1996). Cutting the network. *The Journal of the Royal Anthropological Institute* 2(3): pp. 517–35.

Street, B. (Ed.) (2005). *Literacies across Educational Contexts: Mediating Learning and Teaching.* Philadelphia: Caslon Publishing.

Stewart, T. (1996). The Invisible Key to Success. *Fortune Magazine. August, 5.*

Sundararajan, A. (2017). *The Sharing Economy: The End of Employment and the Rise of Crowd-Based Capitalism*, Cambridge, Mass: MIT Press.

Sundmaeker, H., Guillemin, P., Friess, P., and Woelffle, S. (2010). *Vision and Challenges for Realising the Internet of Things.* European Union.

Sundmaeker, H., Guillemin, P., Friess, P., and Woelfflé, S. (2010). Vision and challenges for realising the Internet of Things. *Cluster of European Research Projects on the Internet of Things, European Commission.*

Sunstein, C. R. (2001). *Republic.com*. Princeton, NJ: Princeton University Press.

Surowiecki, J. (2004). *The Wisdom of Crowds*. NY: Anchor Books.

Sweetser, E. (1990). *From etymology to pragmatics: Metaphorical and cultural aspects of semantic structure* (Vol. 54). Cambridge University Press.

Szerszynski, B. (2003). Technology, performance and life itself : Hannah Arendt and the fate of nature. *The Sociological Review*, 51(2), pp. 203–218.

Tacchi, J.A., Slater, D., and Hearn, G.N. (2003). *Ethnographic action research: A user's handbook*. Unesco.

Tan, L., and Wang, N. (2010). Future internet: The internet of things. In *3rd International Conference on Advanced Computer Theory and Engineering (ICACTE),* Vol. 5, IEEE, pp. 376-380.

Tanaka, K. (2007). *An Introduction to Fuzzy Logic for Practical Applications*. Berlin, Heidelberg: Springer.

Tannen, D. (1989). T*alking Voices: Repetition, Dialogue, and Imagery in Conversational Discourse.* Cambridge England/ New York: Cambridge University Press.

Terranova, T. (2004). *Network Culture: Politics for the Information Age*. London: Pluto Press.

Terranova, T. (2000). Free Labor : Producing Culture for the Digital Economy. *Social Text*, 18(2), pp. 33–58.

Theilman, S., and Hunt, E. (2016). Cyber attack: hackers 'weaponised' everyday devices with malware. *The Guardian,* Saturday 22 October 2016, Retrieved on 17 March 2017 from https://www.theguardian.com/technology/2016/oct/22/cyber-attack-hackers-weaponised-everyday-devices-with-malware-to-mount-assault?CMP=Share_iOSApp_Other

ThingsCon. (2018). *The State of Responsible Internet of Things 2018*. Report by ThingsCon e.V., Berlin.

Thrift, N. (2000) Afterwords. *Environment and Planing D: Society and Space*, 18, pp. 213-255.

Thrift, N. (2009). Space: The Fundamental Stuff of Human Geography. In *Key Concepts in Geography,* SAGE Publications. pp. 95–107.

Thrift, N. (2003). Closer to the machine? Intelligent environments, new forms of possession and the rise of the supertoy. *Cultural Geographies,* 10, pp. 389-407.

Thrift, N. (2004). Movement-space: The changing domain of thinking resulting from the development of new kinds of spatial awareness. *Economy and Society*, 33(4), pp. 582-604.

Toffler, A. (1980). *The Third Wave.* London: Pan Books.

Toonders, J. (2014). Data Is the New Oil of the Digital Economy. *The Wired.* Retrieved on 1 April 2017, form https://www.wired.com/insights/2014/07/data-new-oil-digital-economy/

Townsend, J. G. (1949). Investigation of the Smog. Incident in Donora, Pa., and Vicinity. *American Journal of Public Health,* 40(2), pp. 183–189.

Townsend, A. (2015). Cities of Data: Examining the New Urban Science. *Public Culture* 27(2): pp.201–12.

Trifa, V., Guinard, D., and Mayer, S. (2011). Leveraging the Web for a Distributed Location-aware Infrastructure for the Real. In *REST: From Research to Practice,* pp. 1–19.

Turner, V. (1969). *The Ritual Process: Structure and Anti-Structure*. Chicago: Aldine Transaction.

Tuters, M., and Varnelis, K. (2006). Beyond Locative Media. Retrieved on 20 July 2012, from http://networkedpublics.org/locative_media/beyond_locative_media

Uckelmann, D., Harrison, M., and Michahelles, F. (2011). An architectural approach towards the future internet of things. In *Architecting the internet of things.* Springer Berlin Heidelberg, pp. 1-24.

University of the West of England (UWE) (2013). Science For Environment Policy In-Depth Report*: Environmental Citizen Science*.

Urbinato, D. (1994). London's historic pea-soupers'. *EPA (Environmental Protection Agency) Journal; (United States), 20*.

D'Urso, S. C., and Rains, S. A. (2008). Examining the scope of channel expansion: A test of channel expansion theory with new and traditional communication media. *Management Communication Quarterly*, 21(4), pp. 486-507.

Utell, M. J., Warren, J., and Sawyer, R. F. (1994). Public health risks from motor vehicle emissions. *Annual Review of Public Health,* 15(1), pp. 157–178.

Utratel, A. M. (2016). The Commons Collaborative Economy explodes in Barcelona. Retrieved on 1 April 2017 from http://commonstransition.org/commons-collaborative-economy-explodes-barcelona/

Vaananen, K. (1993). Interfaces to hypermedia: Communicating the structure and interaction possibilities to the users. *Computing and Graphics* 17(3), pp. 219-228.

Vanolo, A. (2014). Smartmentality: the smart city as disciplinary strategy. *Urban Studies*, 5 (5) , pp. 881-896.

Vann, K., and Bowker, G. C. (2001). Instrumentalizing the Truth of Practice 1. *Social Epistemology*, 15(3), pp. 247–262.

Vaughan, A. (2016, Jan 8). London takes just one week to breach annual air pollution limits. *The Guardian.*

Vazquez, J. I. (2007). A Reactive Behavioural Model for Context-Aware Semantic Devices.

Vazquez, J., and Lopez-De-Ipina, D. (2008). Social devices: autonomous artefacts that communicate on the internet. *The Internet of Things*, pp. 308-324.

Vidal, J., and Helm, T. (2016). Shock figures to reveal deadly toll of global air pollution. The Guardian. Retrieved on 1 April 2017, from https://www.theguardian.com/environment/2016/jan/16/world-heslth-organisation-figures-deadly-pollution-levels-world-biggest-cities

Vincenti, W. G. (1993). What Engineers Know and How They Know It: Analytical Studies from Aeronautical History. The Johns Hopkins University Press.

Vanolo, A. (2014). Smartmentality: the smart city as disciplinary strategy. In *Urban Studies*, *51,* (5) , pp. 881-896.

von Klot, S., Wölke, G., Tuch, T., Heinrich, J., Dockery, D. W., Schwartz, J., and Peters, A. (2002). Increased asthma medication use in association with ambient fine and ultrafine particles. *European Research Journal*, 20(3), pp. 691–702.

Wang, R. R. (2012). The Internet of Things and Change - Will You Be Ready For The M2M World? *Forbes*, Retrieved on 1 April 2017, from https://www.forbes.com/sites/raywang/2012/07/23/research-overview-the-internet-of-things-and-change/#59ffb02dc484

Wald, E.R. (2018). Why big tech companies are losing people’s trust. Retrieved on 1 January 2019 from http://www.arabnews.com/node/1306731

Waldbott, G. L. (1978). *Health effects of environmental pollutants (2nd ed.)*. Missouri, USA: The CV Mosby Company.

Walther, J. B. (2011). Theories of Computer - Mediated Communication and Interpersonal Relations. In *The handbook of interpersonal communication,* pp. 443–479.

Walton, B. H., Dajnak, D., Beevers, S., Williams, M., Watkiss, P., and Hunt, A. (2015). Understanding the *Health Impacts of Air Pollution in London.* For: Transport for London and the Greater London Authority. King’s College London.

Ward, M. (2012). Europe hits old internet address limits. *BBC*. Retrieved on 1 May 2018 from http://www.bbc.co.uk/news/technology-19600718

Weber, R. H. (2010). Internet of Things - New security and privacy challenges. *Computer Law & Security Review*, 26(1), pp. 23–30.

Weber, R. H. (2011). Accountability in the Internet of Things. *Computer Law & Security Review*, 27(2), pp. 133–138.

Weinberg, B. D., and Williams, C. B. (2006). The 2004 US Presidential campaign: Impact of hybrid offline and online “meetup” communities. *Journal of Direct Data and Digital Marketing Practice*, 8(1), pp. 46-57.

Weiser, M. (1991). The Computer for the 21st Century. *PERVASIVE Computing. Scientific American*, pp. 18–25.

Weiser, M., and Brown, J. S. (1995). Designing Calm Technology. Xerox PARC. Retrieved on 17 March 2017 from http://www.ubiq.com/hypertext/weiser/calmtech/calmtech.htm

Weiser, M., Gold, R., and Brown, J. S. (1999). The origins of ubiquitous computing research at PARC in the late 1980s. *IBM Systems Journal,* 38(4), pp. 693-696.

Weiss, R. J., and Craiger, J. P. (2002). Ubiquitous Computing. The Industrial-Organizational Psychologist, 39(4), pp. 44-52.

Wellman, B., and Hampton, K. (1999). Living Networked in a Wired World. *Contemporary sociology*, 28(6), pp. 1-12.

Wellman, B., Boase, J., and Chen, W. (2002). The networked nature of community: online and offline. *It & Society,* 1(1), pp. 151-165.

Wellman, B. (2001). The Persistence and Transformation of Community: From Neighbourhood Groups to Social Networks. *Report to the Law Commission of Canada.*

Wenger, E. (1998). Community of Practice: a Brief Introduction. *Learning in Doing*, 15, pp. 1-7.

Wenger, E. (1998). Communities of Practice: Learning as a Social System. *Systems Thinker* 9 (5), pp.2-3.

Wenger, E. (2006). Communities of practice. Communities of practice a brief introduction, pp. 3-13.

Wenger, E., McDermott, R., and Snyder, W. M. (2002). *Cultivating Communities of Practice: A Guide to Managing Knowledge.* Cambridge, Mass: Harvard Business School Press.

Wenger, E. (2009). Communities of practice and social learning systems : the career of a concept. In Blackmore, C. (Ed.), *Social Learning Systems and Communities of Practice,* pp. 179-198. Springer.

Whatmore, S. (2006). Materialist returns: practising cultural geography in and for a more-than-human world. *Cultural Geographies*, 13, pp. 600-609.

Wheat, R. E., Wang, Y., Byrnes, J. E., and Ranganathan, J. (2013). Raising money for scientific research through crowdfunding. *Trends in ecology & evolution*, 28(2), pp.71-72.

Whittemore, A. S. (1981). Air pollution and respiratory disease. *Annual Review of Public Health,* 1(1), pp. 397-429.

Whittle, A., and Spicer, A. (2008). Is actor network theory critique?. *Organization studies*, 29(4), pp. 611-629.

WHO. (2016). Burden of disease from ambient and household air pollution. Retrieved on 16 June 2016 from http://www.who.int/en/

Wiesmaier, A., and Kikiras, P. (2015). A View on Privacy & Trust in IoT. *IEEE ICC, Workshop on Security and Privacy for Internet of Things and Cyber-Physical Systems*, pp. 2665–2670.

Williams, B. (1985). *Ethics and the Limits of Philosophy*. Cambridge, Mass: Harvard University Press.

Williams, B. (1981). *Internal and External Reasons in his Moral Luck*. Cambridge: Cambridge University Press.

Williams, B. (1995). *'Internal Reasons and the Obscurity of Blame' in his Making Sense of Humanity*. Cambridge: Cambridge University Press.

Willis, P. (2001). The ‘Things Themselves’ in Phenomenology. *Indo-Pacific Journal of Phenomenology,* (April), pp. 1–12.

Winner, L. (1993). Upon Opening the Black Box and Finding it Empty: Social Constructivism and the Philosophy of Technology. *Science, Technology and Human Values,* 18(3), pp. 362-378.

Wittel, A. (2000). Ethnography on the move: From field to net to Internet. In *Forum Qualitative*

Sozialforschung/Forum: Qualitative Social Research 1, (1).

Wjst, M., Reitmeir, P., Dold, S., Wulff, A., Nicolai, T., von Loeffelholz-Colberg, E. F., and von Mutius, E. (1993). Road traffic and adverse effects on respiratory health in children. *British Medical Journal,* 307(6904), pp. 596–600.

Wolfert, S., Ge, L., Verdouw, C., and Bogaardt, M. J. (2017). Big data in smart farming–a review. *Agricultural Systems*, *153*, 69-80.

Wolfson, S. (2018). Amazon's Alexa recorded private conversation and sent it to random contact. *The Guardian.* Retrieved on 1 November 2018, from https://www.theguardian.com/technology/2018/may/24/amazon-alexa-recorded-conversation

Woolley, L. A. (2017). In the digital age, data is gold and trust is the key. Retrieved on 1 June 2017, from http://www.fiercecmo.com/special-report/digital-age-data-gold-and-trust-key

Wong, J.C. (2018). Amazon working to fix Alexa after users report random burst of 'creepy' laughter. The Guardian. Retrieved on 1 November, 2018, from https://www.theguardian.com/technology/2018/mar/07/amazon-alexa-random-creepy-laughter-company-fixing?CMP=fb_gu

Wortham, S. (2008). Linguistic Anthropology. Retrieved on 1 May 2017 from https://repository.upenn.edu/gse_pubs/16/

Wright et al. (Eds.) (2010). Safeguards in a World of Ambient Intelligence: Introduction. *The International Library of Ethics, Law and Technology*, Vol. 1, pp. 1–9.

Wu, Q., Member, S., Ding, G., Member, S., Xu, Y., and Member, S. (2014). Cognitive Internet of Things: A New Paradigm Beyond Connection. *IEEE Internet of Things*, *1*(2), pp. 129-143.

Yakowitz, J. (2011). Tragedy of The Data Commons. *Harvard Journal of Law & Technology*, 25,(1).

Yap, R. (2012). How to Build an AirCasting Air Monitor. Retrieved on 16 June 2016, from habitatmap.org/habitatmap_docs/HowToBuildAnAirCastingAirMonitor.pdf

Yeomans, M. (2012). The internet of things: how connected devices can drive sustainability. *The Guardian*. Retrieved on 25 July 2012 from http://www.guardian.co.uk/sustainable-business/internet-of-things-connected-devices

Yin, R. K. (2003). *Case Study Research - Design and Methods (3rd ed).* London: Sage Publications.

Yoo, Y. (2010). Computing In Everyday Life: A Call For Research On Experiential Computing. *MIS Quarterly,* 34(2), pp. 213–231.

Zandbergen, D. (2017). "We Are Sensemakers": The (Anti-)politics of Smart City Co-creation. *Public Culture.* Published by Duke University Press. pp.539-562.

Zegher, C. (1999). *Drawing Papers 3, Another City for Another Life: Constant's New Babylon. An Homage to Constant.* New York: The Drawing Center. p.3.

Zhang, K., Han, D., and Feng, H. (2010). Research on the complexity in Internet of Things. *International Conference on Advanced Intelligence and Awareness Internet (AIAI 2010)*, 1.

Zouganeli, E., and Svinnset, I. E. (2009). September. Connected objects and the Internet of things - A paradigm shift. In *International Conference on Photonics in Switching. PS'09. IEEE,* pp. 1-4.

Zualkernan, I., and Aloul, F. (2010). A Mobile GPRS-Sensors Array for Air Pollution Monitoring. *IEEE Sensors Journal*, 10(10), pp. 1666–1671.1ndr41973

10

APPENDIXES

Appendix I: List of Recorded Events

September 1, 2011	Audio Recorded	Attended	Usman Haque presentation	London Hackspace
October 20, 2011		Attended	London IoT meetup	The Fox Pub, London
November 16, 2011		Attended	London IoT meetup	Harrison Bar, London
December 14, 2011		Attended	London IoT meetup	Centre for Creative Collaboration
January 12, 2012	Video Edit		NY IoT Meetup	Bar One, NY
January 20, 2012	Video Recorded	Attended	London IoT meetup	The Reliance Pub, London
January 21, 2012	Video Edit		Amsterdam IoT Meetup	Cafe de Jaren, Amsterdam
February 16, 2012	Video Recorded	Attended	CCS Workshop	University College London
February 17, 2012	Video Recorded	Attended	CCS Workshop	University College London
February 18, 2012	Video Recorded	Attended	London IoT meetup	University College London
March 16, 2012	Video Recorded	Attended	Intro to Data-Making Workshop	Pachube HQ, London
March 28, 2012	Video Recorded	Attended	Intro to Data-Making Workshop	Centre for Creative Collaboration
March 29, 2012	Video Recorded	Attended	Air Quality Egg Workshop	Centre for Creative Collaboration
April 19, 2012		Attended	Internet of Things Meetup 7	Tech Hub, London
May 22, 2012	Video Recorded	Attended	Internet of Things Meetup 8	Crayon London
June 16, 2012		Attended	Open IoT Assembly	Google Campus, London
June 17, 2012		Attended	Open IoT Assembly	Google Campus, London
July 26, 2012		Attended	Internet of Things Meetup 10	COSM HQ, London
February 19, 2013		Attended	Internet of Things Meetup 18	COSM HQ, London

Films Published by Ilze Strazdina (Black)

IoT London Meetup Jan 2012	https://vimeo.com/40019578
IoT New York Meetup Jan 2012	https://vimeo.com/36209946
IoT London Meetup March 2012	https://vimeo.com/40471645
Making Sense: AirQualityEgg challenge	https://vimeo.com/39775046

Appendix II: List of Interviews

Date	Code	Name	Place	Format	Gend	Nat
120120	IC	Ben Pirt	London IoT Meetup 3	dv+text	M	London
120218	IC1	Alex Roest	Citizens Cyberscience Summ	dv+text	M	Amsterdam
120218	IO3	Alexandra Deschamps-Sonsin	Citizens Cyberscience Summ	dv+text	F	London
120217	IO2	Casper Koomen	Citizens Cyberscience Summ	dv+text	M	Amsterdam
120218	IO1	Ed Borden	Citizens Cyberscience Summ	dv+text	M	NY
120218	IC3	Joseph Saavedra	Citizens Cyberscience Summ	dv+text	M	NY
120218	IC4	Leif Perciefield	Citizens Cyberscience Summ	dv+text	M	NY
120217	ICI5	Martin Dittus	Citizens Cyberscience Summ	dv+text	M	Berlin/London
120217	ICI6	Alison Wheeler	Citizens Cyberscience Summ	dv+text	F	London
120218	ICI7	PaulTanner	Citizens Cyberscience Summ	dv+text	M	London
120317	WP9	Christial Nold	CCC	dv+text	M	London
120317	WP1	Dorien Zandbergen	CCC	dv+text	F	Amsterdam
120317	WP6	Ashley Mills	CCC	dv+text	M	London
120317	WP7	Cesar Garcia	CCC	dv+text	M	Madrid
120317	WP3	Cindy Regalado	CCC	dv+text	F	London
120317	WP5	Stephen Harrison	CCC	dv+text	M	London
120317	WP8	Sara Alvarellos	CCC	dv+text	F	Madrid
120317	WP4	Paul Allen	CCC	dv+text	M	London
120617	Bosh	Stefan Ferber	Open IoT Assembly	dv+text	M	Germany
150312	IO	Ed Borden	Skype	audio+text	M	NY

Code Keys

IC - Interview Coder
IO - Interview Organiser
ICI - Interview Coder Independent
WP - Workshop Participant

Appendix III: Coding Keys

...	Three dots indicate untimed pause.
(2.5)	Number in brackets indicate length of pause in seconds
=	Equal signs indicate ‘latching’, that is no interval between two adjacent utterances.
Em	Audible inhalations.
((LG))	Laughter.
((smiles))	Material between double brackets provides information of bodily movements.

Appendix IV: Community's Online Spaces

Pachube (old site offline now)	https://pachube.com
Pachube Facebook site	https://www.facebook.com/Pachube-219870201078/
Xively site	https://www.xively.com/
IoT/Sensmakers NY	https://www.meetup.com/sensemakers/
IoT/Sensmakers Amsterdam	http://www.meetup.com/sensemakersams/
IoT London	http://www.meetup.com/iotlondon/
IoT Madrid	http://www.meetup.com/iotmadrid/
IoT Barcelona	http://www.meetup.com/iotbarcelona/
IoT Munich	http://www.meetup.com/iotmunich/
IoT Zurich	http://www.meetup.com/IoT-Zurich
AQE community portal	http://airqualityegg.com/
AQE Kickstarter Project	https://www.kickstarter.com/projects/edborden/air-quality-egg
AQE Wiki space	http://airqualityegg.wikispaces.com
AQE mailing list	https://groups.google.com/forum/#!forum/airqualityegg
AQE Twitter	https://twitter.com/The_AQE
WickedDevice Forum	http://forum.wickeddevice.com/
WickedDevice Shop	http://shop.wickeddevice.com
AQE codes by Victor Aprea	http://solderpad.com/vicatcu/
AQE codes by Joe Saavedra	https://github.com/jmsaavedra/Air-Quality-Egg
AQE sensors By WickedDevice	https://github.com/WickedDevice/AQE_SENSORMODULE_E2V_CMOS
AQE Chicago Workshop	https://github.com/jmsaavedra/AQE-Workshops/tree/master/July2012_Chicago

AQE community's other video documentations

#iot #afterhours 2	http://vimeo.com/36392308
#iot #afterhours 1	http://vimeo.com/36393947
Vertical Axis Wind Turbines in South Africa on Pachube	http://vimeo.com/38236869
Talking air quality data interoperability at #EcoHackNYC #AirQualityEg	http://vimeo.com/40867990
Air Quality Egg @ EcoHackNYC	http://vimeo.com/42016970
Chicago #AirQualityEgg Hackshop Day 1 Enclosure Team Report	http://vimeo.com/46329193
Chicago #AirQualityEgg Hackshop Day 1 Data Team Report	http://vimeo.com/46329216
Chicago #AirQualityEgg Hackshop Day 1 Deployment Team Report	http://vimeo.com/46329304
Chicago #AirQualityEgg Hackshop Day 2 enclosures coming off the line	http://vimeo.com/46378984
Chicago #AirQualityEgg Hackshop Dataviz @adam_lasko	http://vimeo.com/46393661
Electric Imp to COSM	http://vimeo.com/48095200
#AirQualityEgg radiation circuit prototype	http://vimeo.com/48100108
Websocket workshop at PICNIC	http://vimeo.com/50583146
Energy Generating bike wheel live demo	http://vimeo.com/51355615
Light sensor -> COSM -> Node.js -> Visualight	http://vimeo.com/51408952
Visualight showing real time MTA bus status	http://vimeo.com/51409341
Max msp -> Node.js -> COSM via websockets	http://vimeo.com/51453635
AirQualityEgg workshop in NYC, late 2011	http://vimeo.com/51464734
Air Quality Egg Hackday in Amsterdam, early 2012	http://vimeo.com/51464736
Android ADK -> Websockets -> COSM -> and back	http://vimeo.com/52102151
AirQualityEgg Kickstarter video	http://vimeo.com/58898280

Open IoT Assembly Online Space

Pachube Internet of Things Bill of Rights
https://engadgeted.wordpress.com/2011/03/27/pachube-internet-of-things-bill-of-rights/

Open IoT Assembly Statement
https://docs.google.com/document/d/1yZAsNaesDocqqtkFgucbFS_zE4tDP1Jsfszsvls7Yuc/edit?pli=1
https://www.wired.com/2012/06/the-provisional-declaration-of-the-open-internet-of-things-assembly/

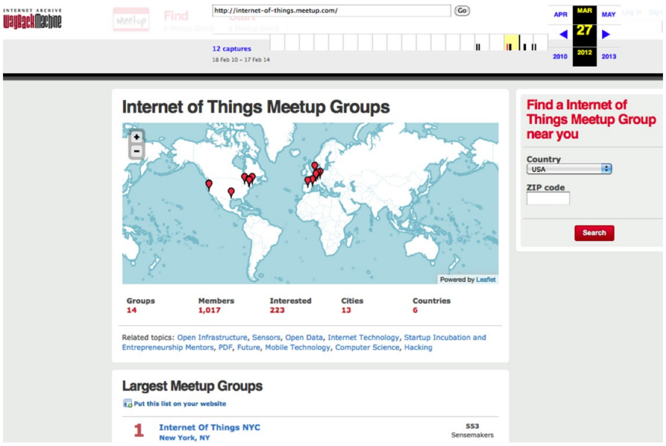
Open IoT on docs on postscapes
https://www.postscapes.com/open-internet-of-things-assembly/

Open IoT Assembly on Flickr
https://www.flickr.com/photos/alexandra666/sets/72157630192407708/

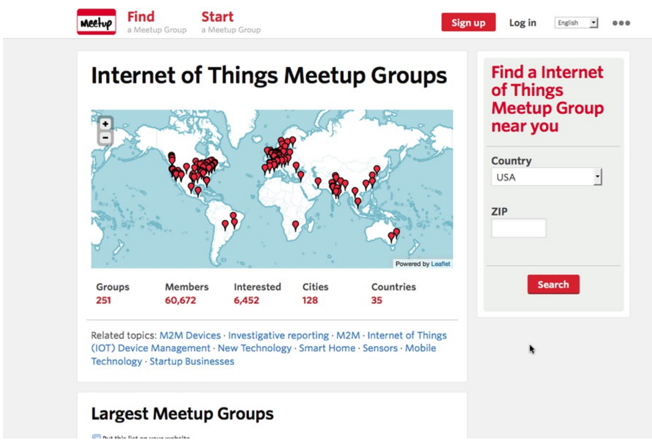
Open IoT Assembly Twitter https://twitter.com/openiot

Appendix V: IoT Meetup Genealogy

1. IoT Meetups Map in May 2012



2. IoT Meetups Map August 2014



	Set Up Date	Meetup Name	Location	No
1	Nov 20, 2003	The Tucson IOT Meetup Group	Tucson, AZ;	1
2	Feb 21, 2009	Internet of Things (SF/SV)	San Francisco, CA;	2230
3	Sep 9, 2010	**Sensemakers NYC**	New York, NY;	760
4	Sep 29, 2011	**Sensemakers Amsterdam**	Amsterdam, NL;	790
5	Oct 4, 2011	**Internet of Things London**	London, UK;	3315
6	Oct 8, 2011	**Internet of Things Barcelona**	Barcelona, Spain;	1158
7	Oct 10, 2011	**IoT Zurich**	Zürich, Switzerland;	504
8	Nov 14, 2011	**Internet of Things Madrid Meetup**	Madrid, Spain;	686
9	Feb 9, 2012	**Internet of Things Munich**	München, Germany;	395
10	Mar 26, 2012	IoTBayArea	Berkeley, CA;	138
11	Mar 30, 2012	IoTSiliconValley	San Jose, CA;	1053
12	Apr 28, 2012	Internet of Things Hardware Startups	Toronto, ON	794
13	May 7, 2012	San Francisco Internet of Things Meetup (@SFIoTMeetup)	San Francisco, CA;	2058
14	Sep 14, 2012	Cambridge Internet of Things	Cambridge, UK;	342
15	Oct 29, 2012	The Open Source Internet Of Things Silicon Valley - OSIOT	Sunnyvale, CA;	859
16	Nov 1, 2012	Internet das Coisas na Prática	São Paulo, Brazil;	222
17	Nov 24, 2012	**Internet of Things Bilbao**	Bilbao, Spain;	38
18	Dec 29, 2012	IoTTwinCitiesMN	Minneapolis, MN;	94
19	Jan 22, 2013	Thing Tuesday - The Portland Internet of Things Meetup	Portland, OR;	506
20	Jan 27, 2013	PDX Internet of Things	Portland, OR;	87

Appendix VI: Pachube Community Related IoT Meetup Design Interfaces 2011-2017

1. London IoT Meetup banner since 2011 – present (2017)

2. Barcelona IoT Meetup banner since 2011 – present (2017)

3. Madrid IoT Meetup banner since 2011 – present (2017)

4. Berlin IoT Meetup banner since 2013 – present (2017)

5. Zurich IoT Meetup banner since 2011 – present (2017)

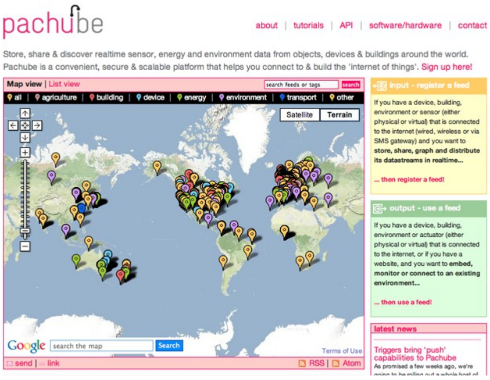
6. New York* IoT Meetup banner since 2013 – present (2017)

* The banner was featured on the original NY IoT meetup site, set up by Ed Borden in 2011. In 2013, the original site was renamed as sensemak.rs and the same year the current (new) site was set up (mirroring same identity and design features)

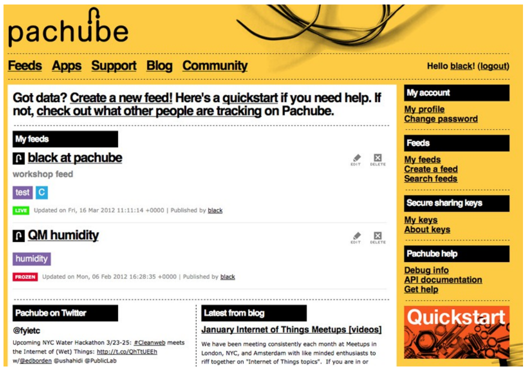
Appendix VII: List of AQE Kickstarter Pledges and Rewards

Amour	No of	Del Date	Reward
			Application beta tester of open data
1$	155	01/07/12	Represent DIY air quality monitoring with a T-Shirt and Sticker set that we promise will not be lame
30$	16	01/05/12	Custom air quality sensor shield for Arduino with ability to sense NO2, CO, temp, humidity. This will allow you to build your own sensor sy
40$	39	01/07/12	Air quality sensor Arduino shield + shipping costs
53$	20	01/07/12	Wired (ethernet/power to outside sensor box) air quality sensor box only, in DIY kit form (parts in a bag with tutorial). This will allow you t
70$	52	01/07/12	Wired DIY sensor box + shipping costs non -US
83$	34	01/07/12	Air Quality Egg. Fully assembled, Plug and Play, wireless air quality sensing system. Generates NO2, CO, temperature and humidity data ar
100$	329	01/07/12	Air Quality Egg + shipping costs to any non-US address
113$	147	01/07/12	
250$	101	01/07/12	Air Quality Egg + O3, VOC, Radiation, and Dust/Particulate sensor upgrades. Shipping to US included, add $13 for international shipping.
2500$	2	01/08/12	Air Quality Egg on-site workshop for 30 people. We will come to you with parts to build 30 wired air quality sensor boxes and build them w
10000$	4	01/08/12	Sensor up a CITY. Let's do a big rally to kick it off. We'll come with 100 Air Quality Eggs, run a clinic, do some talks about sensing/science

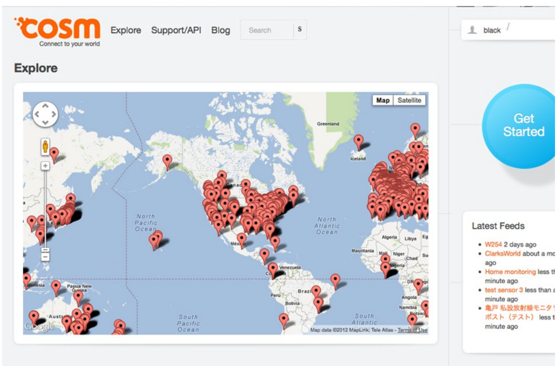
Appendix VIII: Pachube, COSM, Xively Site Interfaces



Pachube 2009



Pachube 2011



COSM 2012

Xively 2013

Appendix IX: Pachube, COSM, Xively Graph Interfaces

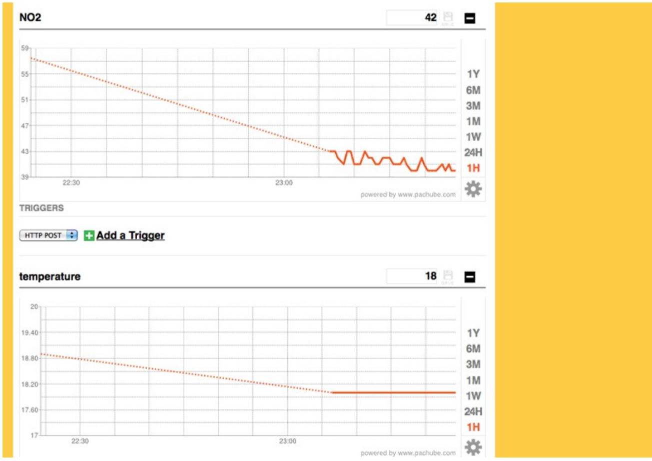


Image 1: Pachube Graph Interface December 2011

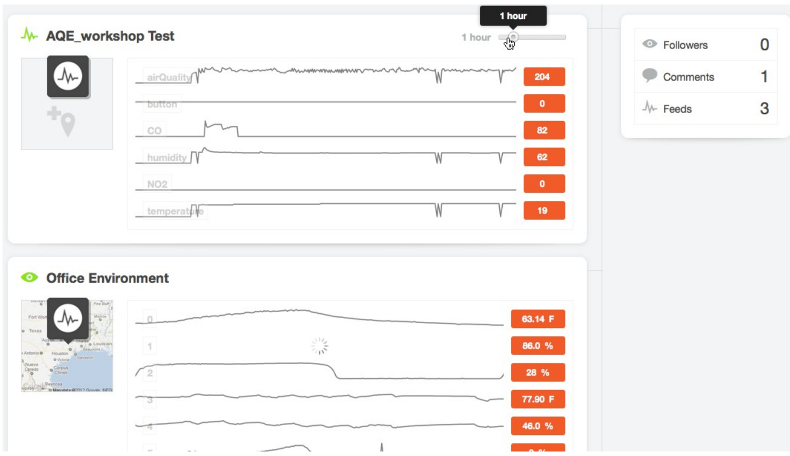


Image 2: COSM Graph Interface May 2012

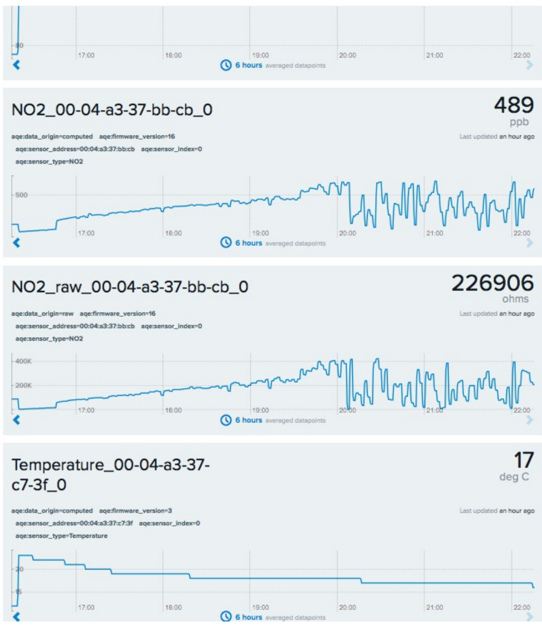


Image 3: Xively Graph Interface May 2013

Appendix X: AQE Device Data

```
REQUEST: 227
PUT http://api.pachube.com/v2/feeds/53816.csv HTTP/1.0
Host: api.pachube.com
X-PachubeApiKey: kI5hzJTW80Tv_detORcUHCRccp9Yr8SolD7oTPrJy8Q
Content-Length: 64
NO2,0
CO,0
airQuality,0
humidity,0
temperature,0
button,0
REPLY:
HTTP/1.1 200 OK
Date: Fri, 06 Apr 2012 13:24:43 GMT
Content-Type: text/plain; charset=utf-8
Connection: close
X-Pachube-Logging-Key: logging.BoRktuWXLaQFUO61HLsG
X-PachubeRequestId: 4a6d562b618a4cb3d46ec3092d9c741255cc69ab
Cache-Control: max-age=0
Content-Length: 1
Age: 0
Vary: Accept-Encoding
>>> RESPONSE RECEIVED ---
currTime: 12
reading sensors
currTime: 14
reading sensors
currTime: 16
reading sensors
currTime: 18
reading sensors
-----BEGIN ATTEMPT SEND DATA-----
sending No2      = 105
sending CO       = 0
sending Quality  = 191
sending Humidity = 42
sending Temp     = 22
sending Button   = 0
```

Image A: Data sent by the device

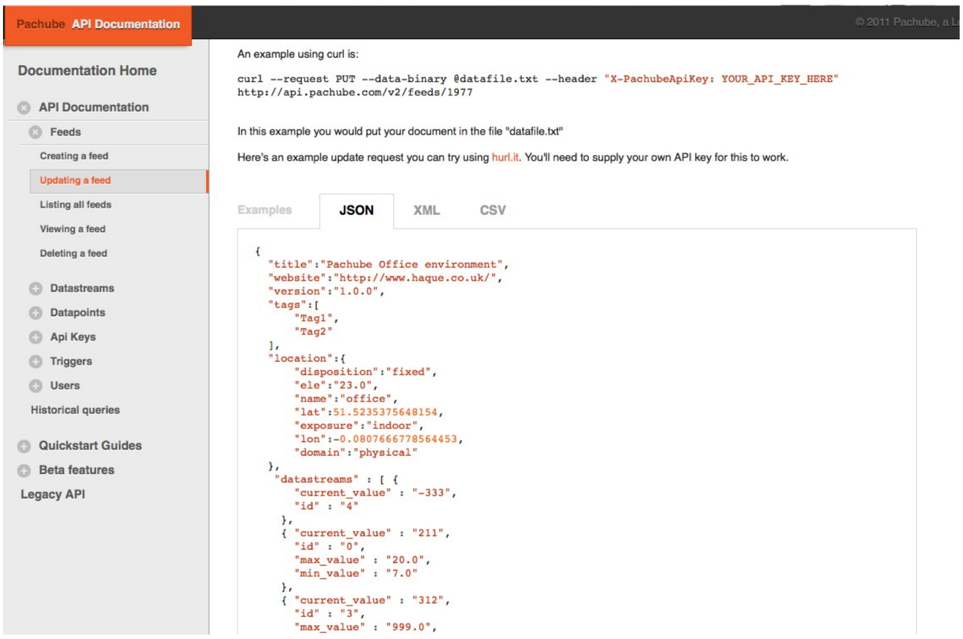
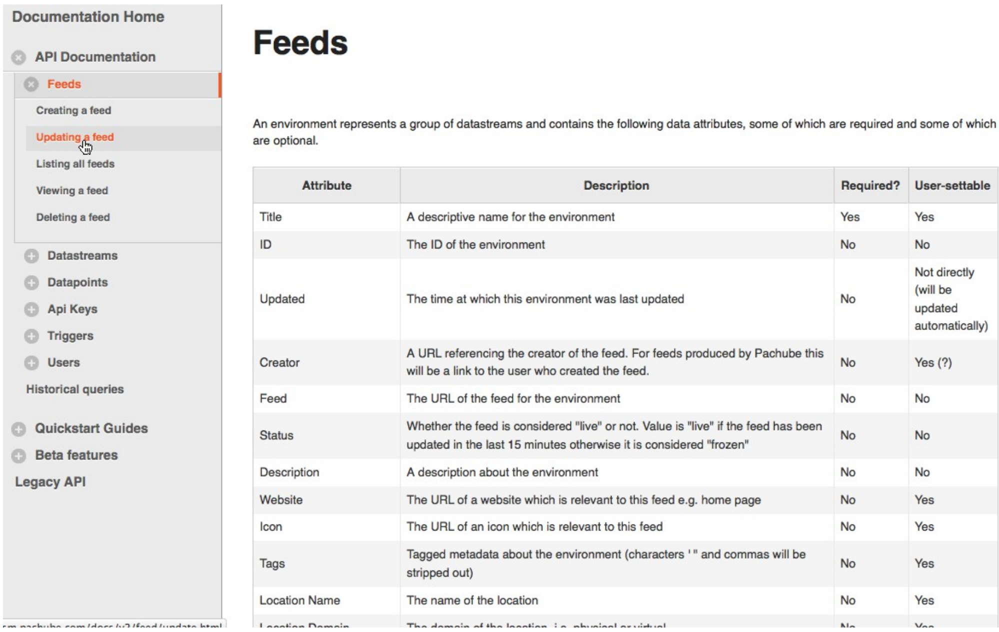


Image B: Data received by the server



Documentation Home

API Documentation

Feeds

Creating a feed

Updating a feed

Listing all feeds

Viewing a feed

Deleting a feed

Datastreams

Datapoints

Api Keys

Triggers

Users

Historical queries

Quickstart Guides

Beta features

Legacy API

Feeds

An environment represents a group of datastreams and contains the following data attributes, some of which are required and some of which are optional.

Attribute	Description	Required?	User-settable
Title	A descriptive name for the environment	Yes	Yes
ID	The ID of the environment	No	No
Updated	The time at which this environment was last updated	No	Not directly (will be updated automatically)
Creator	A URL referencing the creator of the feed. For feeds produced by Pachube this will be a link to the user who created the feed.	No	Yes (?)
Feed	The URL of the feed for the environment	No	No
Status	Whether the feed is considered "live" or not. Value is "live" if the feed has been updated in the last 15 minutes otherwise it is considered "frozen"	No	No
Description	A description about the environment	No	No
Website	The URL of a website which is relevant to this feed e.g. home page	No	Yes
Icon	The URL of an icon which is relevant to this feed	No	Yes
Tags	Tagged metadata about the environment (characters ' " and commas will be stripped out)	No	Yes
Location Name	The name of the location	No	Yes

Image C: Feeds explained in COSM documenation

Appendix XI: Open IoT Assembly Documents

Pachube Internet of Things "Bill of Rights"

1. People own the data they (or their "things") create.
2. People own the data someone else creates about them.
3. People have the right to use and share their data however they want to.
4. People have the right to access their data in a standard format.
5. People have the right to delete or backup their data.
6. People have the right to privacy.

Statement of the Open Internet of Things Assembly at London, United Kingdom on the 17th June, 2012

Licensing provisions

• **Licensors** may explicitly grant rights to third parties (**licensees**) to use their data.

• **Data ownership** should remain with the Licensor.

• **Data feeds** should have human- and machine-readable licenses attached to them.

["Bits should know their rights."]

• We consider data captured by devices compliant with these guidelines to be analogous to any other Digital Commons data. The existing Creative Commons language provides a useful basis for engagement, for example: "Every license helps creators — we call them licensors if they use our tools — retain copyright while allowing others to copy, distribute, and make some uses of their work — at least non-commercially."

• Individuals (who may not be the Licensors) must be granted license to any machine-generated data that is created, collected or otherwise generated that relates to them.

• Individuals (who may not be the Licensors) should have the right to remain anonymous, retain the ability to license data on an anonymous basis, and be offered the ability to license data at whatever available granularity or resolution (e.g. temporal or spatial) is most suited to their purposes.

Goal: Accessibility of data

Data should be released in at least one format, protocol, and **API** with the following characteristics:

• free, public **documentation**

• **royalty**-free to use, indefinitely

• open source **parsers**/**libraries** available

In order to qualify for certification of compliance with these principles, the format, protocol or API in question should feature a minimum of two independent **reference implementations**

Goal: Timeliness of access

Data should be released:

• without imposed delay, based on the accessibility principle above;

• at the **resolution** at which it has been acquired;

• to the **data subject** for as long as the provider hosts the data and for at least a pre-agreed duration of time

Goal: Preservation of privacy

Data subjects should have the rights:

• to know what data is being collected about them, by whom, and for what stated purpose;

• to consent to that collection;

• and to take such measures as are necessary to prevent the collection attempt if they do not consent to it.

Reasonable efforts should be made to protect confidentiality and privacy of the data subject.

Goal: Transparency of process

Data controllers should inform data subjects that deleting all copies of data may be technically unfeasible once published.

Where data is collected from **public space**, data subjects and stakeholders should have a role in decision-making and governance.

Appendix XII: Open IoT Assembly Data Corpus

	K_Rol	Laura	Self	Acces	Acces	Priva	Planet	City	Citiz_	Licens	Tools	Geo_	Owne	Comr	Decisi	D1_ro	K_Us	K_Gav	Licens	Home	panel	final	score	TOTAL
Word Count	4649	4808	4287	1259	3147	1615	5657	1208	2325	7574	550	296	1485	2327	1406	1459	2348	3689	1517	2774	6872	7772		69024
Commons	0	1	1	0	1	0	19	5	0	20	0	0	1	0	0	1	0	0	6	0	2	2	**10**	59
City	7	3	1	3	1	2	0	5	4	5	0	0	1	4	2	0	5	0	0	0	7	0		50
Cities	6	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	4	4	0	0	5	0		16
Change	0	4	1	2	0	0	3	0	1	6	0	0	0	0	2	1	1	22	3	0	0	4		50
China	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	3	0		11
Climate	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	8	2	0	0	0		14
Data	10	93	85	30	82	26	22	31	17	156	0	1	29	5	0	17	27	17	31	46	10	169	**1**	904
Europe	6	2	0	0	0	0	2	0	0	1	0	0	0	2	0	0	0	1	0	0	10	0		24
Governance	2	1	1	1	0	0	10	0	0	0	0	0	0	0	0	2	0	0	1	0	0	11		29
Home	11	3	0	2	0	4	0	0	0	1	0	0	0	0	0	0	2	2	0	22	0	0		47
Internet of Th	0	17	0	1	0	3	19	1	0	6	0	0	3	2	8	1	2	2	3	7	0	8	**6**	83
IoT	13	9	1	0	2	2	1	0	0	1	0	0	0	0	0	2	0	1	1	0	15	5		53
Interoperabilit	3	1	2	0	1	0	1	0	0	0	0	0	0	0	0	2	1	0	0	1	4	0		16
License	0	9	7	0	2	1	0	24	0	35	0	0	14	0	0	9	0	0	7	6	0	81	**3**	195
Market	5	4	3	0	0	0	4	0	0	0	0	0	0	0	1	0	0	3	0	3	13	0		36
Open	15	116	23	3	6	0	14	6	3	11	0	0	0	4	3	1	0	4	8	4	6	8	**2**	235
Public	5	8	10	1	2	3	10	0	5	0	3	0	1	4	2	1	2	0	0	1	14	46	**4**	118
Private	2	3	7	1	3	2	7	0	0	0	0	0	1	0	0	2	0	0	1	8	4	14		55
Privacy	2	10	9	1	1	13	0	2	0	3	0	0	0	0	0	9	0	0	0	7	0	12	**8**	69
Planet	0	1	2	1	0	0	9	0	0	15	0	0	0	0	0	0	4	3	0	0	2	0		37
Rights	0	0	5	7	4	1	3	11	0	19	0	0	4	0	0	1	0	1	1	3	5	17	**7**	82
Smart	13	1	0	0	0	0	0	1	2	3	0	0	0	0	0	1	0	2	0	6	8	0		37
Space	12	4	1	1	1	2	7	0	0	3	0	0	1	1	0	1	0	1	1	6	3	18	**9**	63