

Internet of Things

Technology, Communications and Computing

Series editors

Giancarlo Fortino, Rende (CS), Italy

Antonio Liotta, Eindhoven, The Netherlands

More information about this series at <http://www.springer.com/series/11636>

Alessandro Soro · Margot Brereton
Paul Roe
Editors

Social Internet of Things

Editors

Alessandro Soro
Queensland University
of Technology (QUT)
Brisbane, QLD, Australia

Paul Roe
Queensland University
of Technology (QUT)
Brisbane, QLD, Australia

Margot Brereton
Queensland University
of Technology (QUT)
Brisbane, QLD, Australia

ISSN 2199-1073

Internet of Things

ISBN 978-3-319-94657-3

<https://doi.org/10.1007/978-3-319-94659-7>

ISSN 2199-1081 (electronic)

ISBN 978-3-319-94659-7 (eBook)

Library of Congress Control Number: 2018945462

© Springer Nature Switzerland AG 2019

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Printed on acid-free paper

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

The Internet of Things is here to stay. Looking backwards, it is hard to retrace the steps that led to its creation, as it embodies ideas that have been simmering for decades. The name ‘Internet of Things’ is generally credited to Ashton [1], and his original idea of an intelligent supply chain in which ‘things’ can identify themselves and communicate using networking protocols.

For example, in this vision, a yogurt pot is capable of sensing its environment and monitor its location, from when it leaves the dairy, into the delivery truck, down to the shelf of the supermarket, into our shopping bag, fridge, bin and ultimately all the way to the waste facilities. During its journey, the yogurt pot would speak to intelligent devices to check that the chain of cold wasn’t broken, the product is not past expiry date, the empty jar is going to the proper recycling bin and so on.

This initial scenario is but a fraction of the current, broader vision. Today’s IoT takes inspiration and borrows concepts from a variety of research initiatives, including ubiquitous computing, ambient intelligence, tangible user interfaces, mobile and ad-hoc sensor networks, wearable computing, while maintaining some important differences with each of these. One key aspect that sets the current scenario apart from the fields above is the attention that the IoT is focusing, both from industry and the general public: previous waves of research on pervasive and ubiquitous computing never seemed to particularly capture the imagination of industry and everyday users, and the Ubicomp vision always remained somehow trapped into a perpetual ‘proximate future’ [2], promising but never quite ripe yet.

When looking forward to the market estimates about the IoT, however, the figures dance considerably depending on who makes the forecast, but everyone seems to agree that they will be in excess of the hundreds of billions of dollars per year. The first movers among big industries are attracted by the promise of traceability, reduced waste, improved safety, and real-time monitoring and optimisation [3], and these applications are driving 10-digit investments by big actors in, e.g. health care, food supply chain, mining and logistics. Although key actors are still to emerge, the enabling technology is still evolving and services and protocols are still

fragmented, industry has invested so much that it will deliver an IoT: there is an overall sense of having passed the point of no return.

Under this broad umbrella, the IoT is expanding from the initial vision (today sometimes referred to as *Industrial Internet of Things*, IIoT) to explore the opportunities of interconnecting things of all sorts, making them capable of reasoning about the data they collect and talking to other things. Almost everything, be it a kettle, a fire hydrant, or a motorbike, can be enhanced with sensors, computing and connectivity. Perhaps, it is the tangibility of things, as they are moved around, manufactured, sold, used every day and the possibility of their connection and tracking that makes them irresistible. It is, in fact, when looking closer to the everyday users, at the mundane applications, that the IoT can potentially have the bigger impact, for better or worse. Scattered across the home, embedded in people's cars, even worn as clothes or ornaments, IoT devices can empower or become the instrument of surveillance, engage or deskill, help us to socialise or isolate us even further into our own technological bubble, depending on what standpoint we take in design [4].

Crucially, the Internet of Things we want is not likely to emerge from a technology-driven vision alone. For example, if devices are getting smarter, they don't seem to be getting much wiser. Our appliances, cars, homes and clothes, are becoming more and more nosey and chatty. Internet-connected things, including cars, smart thermostats and door locks, can (and have been) hacked to hand over control to remote attackers. If these issues can be identified and fixed, some 'features' of smart things are even more alarming. From speech activated interfaces responding to TV commercials to robot vacuum cleaners reselling the plan and arrangement of the furniture in our homes, it is becoming progressively clear that a lot of the questions that matter to end users are not central in the current IoT research and development agenda.

Open questions in this sphere move from the details of people's everyday interaction with this novel architecture, to include privacy issues, ethical values and cultural issues. For example [5], how will users control what is communicated? How will they interact with things, and how will things attract their attention? How will people make sense of the things and data? How will people communicate through things?

And delving deeper into the thorny issues, what are the implications of things participating in people's social life? How are privacy and personal boundaries understood and negotiated when things (or through things, service providers) get to know so much about us? What values are implicitly embedded in IoT design, and how do these constitute people's relation with things and with each other? What is lost by delegating agency to smart objects, and what is gained? Finally, what is the value proposition of the IoT to end user? Will people buy (and love) smarter juice squeezers, dog leashes, walking canes, surfboards or is this field still in search of its true soul?

These questions were a starting point for this book, developed through a series of workshops with design researchers and practitioners [6]. Whereas the Internet of Things is often described as a global networking infrastructure [3] (i.e. a special

kind of *Internet*) or a decentralised system of smart objects [7] (i.e. a special kind of *things*), we were determined, like a modern Diogenes, to find the people. We call this vision ‘the Social Internet of Things’, and throughout the ten chapters of this book we set out to explore some of the ramifications of this new computing paradigm.

The first three chapters articulate different visions for the social IoT, with particular attention to how the vision can be situated, respectively, within culture, place and practices.

In Chapter “[Beautifying IoT: The Internet of Things as a Cultural Agenda](#)”, Jeffrey Bardzell, Shaowen Bardzell and Cyn Liu discuss the aesthetics of IoT products, and how these reflect and embody specific cultural sensibilities with implications that reach beyond technology issues and approaches. Moving from philosophy of art and beauty, the authors develop the concept of ‘Beautifying IoT’, i.e. object whose aesthetics is a key element of their experience, and that are conducive to a ‘fuller, freer, and more meaningful way of being’. These aspects, which are almost absent from much of the discourse on IoT (both in Industry and Academia), are illustrated in two case studies from the authors’ ethnographic work in Taiwan. Both cases involve renovation and repurposing in search of a higher sense of beauty: of people’s whole lifestyle in the first case study (former city dwellers and professionals turned to farming and living off the land); and of an industrial material and family-owned business (a zinc alloy production plant turned into designer product manufacturing) in the second. The chapter is a call to action for design researchers in HCI to ‘attend [...] to aesthetic qualities of emerging technologies’, and to do so at much larger scale than that of the traditional interface, app or artefact, as the reach of the IoT infrastructure is global.

Jack Carroll’s ‘Internet of Places’ vision, detailed in Chapter “[The Internet of Places](#)”, aims to capture ‘new kinds of experiences and relationships between people and environments’ that cannot be fully understood within the techno-centric framework that is typical of the Internet of Things discourse, and that, he notes, requires a further layer of analysis (the ‘Social’ IoT) above the issues of ‘data and data handling’. In this view, place is a perfect case study in that its meaning is ‘constructed through interaction and experience’, as opposite to the data describing a location, that can be fully characterised and captured using existing techniques and sensors. Carroll explores this meaning at personal, family and community scale: new data and services infrastructures can enable ‘richer interactions and experiences’, but will surely entail socio-technical trade-offs. For example, configuring and managing security may undermine the vivid agency and partnership of one’s places, compromising the social IoT. These reflections extend to all relations involving people and places, from family to neighbourhood, investing these relations of new meaning, that under the social IoT agenda scholars are only beginning to explore.

In Chapter “[From the Internet of Things to an Internet of Practices](#)”, Thomas Ludwig, Peter Tolmie and Volkmar Pipek extend the reflection on IoT technologies to encompass the ways technologies are situated in *practice*. In the chapter, the authors set off to explore the process of collaborative appropriation, as it can be

supported by the smart interconnected devices that form the Internet of Things. IoT devices and their sensors have often been aimed at the environment (to harvest contextual information) or at their users (to collect behaviour patterns). Ludwig, Tolmie and Pipek, rather tune them to the situated action of professional practice, and imagine an IoT where *things* were capable to sense, share and mediate the nuances of their use in *practice*. Designing a tool, a photo camera in the example offered, as a *sociable technology*, means enabling that tool to sense and share detailed information on use, technical and socio-material context, and even the intention of the photographer (process context), in ways that can be communicated and appropriated by other photographers. The ‘Internet of Practice’ vision then raises the stakes from a current technological focus, towards the more intricate, nuanced and somewhat ephemeral realm of making sense of sharing, supporting and appropriating expert practice.

The next three chapters address aspects of the interaction design of the social IoT.

Nikolas Martelaro and Wendy Ju explore in Chapter “[The Needfinding Machine](#)” how designers may interact with users *through* prototypes to better bring to focus users’ needs. A needfinding machine is a connected device that embeds a ‘conversational infrastructure’ through which designers can observe, communicate and interact with users, as well as remotely control the machine, monitor its status and document the interaction. As a design method, needfinding machines draw upon a vast diversity of related methods, from classic in-the-lab approaches like wizard of Oz to purely in-the-wild ethnographically inspired, passing through methods that enlist *things* as co-ethnographers, opening up unusual perspectives to designers. Applied to the context of the social IoT, needfinding machines additionally help us to focus on issues of privacy and reciprocity, and to do so from the sometimes uncomfortable designers’ perspective, in their role of performing the machine. Schön’s classic description of design as a reflective conversation with a situation is here then taken one step further by likening the user–designer conversation to improvisational theatre, in which ‘unplanned opportunities’ may arise at any time, to ‘understand experience right as it happens’. These remarks may well describe any social interaction, which stresses once more the social nature of the IoT design space.

Donald Degraen in Chapter “[Exploring Interaction Design for the Social Internet of Things](#)” delves deeper into the interaction challenges that users will face in understanding and controlling smart objects. Networks of things that socialise can have countless benign outcomes but also pose challenges. Smart objects need to become trustworthy and able to autonomously socialise. Open questions that had been lingering for a while regarding the intelligibility and control of autonomous, context-aware systems are soon to become more pressing as IoT systems appear on the shelves of the retail market. Will users be aware of what is happening behind the scenes? Will they be able to understand and review the data that is being gathered, and the way it is processed? Will users be able to make sense of the role of each *thing* within the bigger infrastructure? And on what basis shall users trust the information that they receive through their things, or entrust those things with their own personal information? Degraen’s characterisations of this design space address

these questions by unpacking the problem in terms of intelligibility and control on one side, and modelling the behaviour of social IoT objects giving them predictable personalities, on the other.

Maliheh Ghajargar, Mikael Wiberg and Erik Stolterman address how smarter objects and places will influence peoples' reflective thinking. On the one hand, the authors note, peoples' thinking is largely reliant on their interactions with objects and things. On the other hand, things are more and more 'computational, smart, networked and interconnected'. In this vision, our very thinking becomes part of a larger interconnected system, reflection is always socially and spatially situated, and the social IoT is better understood as a relational approach to the design of '*Places for Reflection*'. The relations to focus on are unpacked in the chapter, taking the 'place' as a cornerstone to which the reciprocal dependencies of objects, people and activities are anchored. So the presence of certain smart objects in a space will characterise that as a place for the kind of reflective thinking that is enabled by those objects, the performance of specific activities involving those objects will give meaning to the built environment; and people will inhabit these places creating there their own culture. But if the whole may escape our awareness, the specific relations that bind together places, objects, people and activities offer a suitable unit of analysis to make sense of the social IoT design space.

The following four chapters explore applications of the social IoT at different scales, from the home, to the workplace, the care centre and the community.

Using a toolkit of their own design, Arne Berger, Andreas Bischof, Sören Totzauer, Michael Storz, Kevin Lefevre and Albrecht Kurze explored use scenarios of IoT in the social context, the social implications of IoT data and how to engage people in participatory explorations of IoT applications; their reflections are the subject of Chapter "[Sensing Home: Participatory Exploration of Smart Sensors in the Home](#)". IoT devices and sensors can be deployed in many different situations to harvest environmental data in the home, enabling people to freely explore the possibilities of the technology and make sense of its limitations; or they can be used to support teaching in the wild, which offers insights into how the IoT can be appropriated into real practices, and on the complexity of contextualising the information gathered; or finally they can be tuned and positioned in ways that reveal unexpected traces of everyday life, raising interesting implications on the ethics of surveillance in private spaces by family members that are seldom explored in current research, and overall showing how open IoT toolkits can be used to explore and generate many different research and design directions.

Markus Rittenbruch and Jared Donovan bring the exploration into the workplace in Chapter "[Direct End-User Interaction with and Through IoT Devices](#)" in a quest to understand the growing tensions between increasing automation on one side and the availability of inexpensive and programmable tangible interfaces on the other. Their study shows that when personal devices are used to negotiate collective boundaries people will resort to varied and sometimes hard to reconcile strategies, also depending on subjective perceptions of comfort with the current situation, of alignment with the general preference, and on the feeling of agency, reciprocity and respect (or lack thereof). Rittenbruch and Donovan described how the design can

de-emphasise some aspects (and reasons for tension) in favour of others, but also how the physical level (of temperature, settings and sensors) and the social level (of negotiation of preferences, respect for boundaries and feelings of comfort) will always interact in situated and subjective ways.

Chapter “[Engaging Children with Neurodevelopmental Disorder Through Multisensory Interactive Experiences in a Smart Space](#)” by Franca Garzotto, Mirko Gelsomini, Mattia Gianotti and Fabiano Riccardi explores applications of the IoT to create a platform capable of supporting multimodal multisensory activities that promote motor coordination, attention and social interaction, for children with neurodevelopmental disorder. Here, the IoT has the potential to greatly improve the quality of life of children and their families, as well as supporting the daily work of therapists. The challenge, however, for a technological vision that is aiming at mass production and mainstream adoption, is to adapt to the individual needs and pace of each young user. For this to happen, end-user development paradigms should join forces with IoT initiatives, so that therapists, families and patients can design personalised, unique interventions that match the therapists’ educational goals and the children’s needs.

Can Liu, Mara Balestrini and Giovanna Nunes Vilaza finally present their reflections on the opportunities for social engagement with IoT, related to places and communities. When design is aimed to foster positive change, communities are a natural partner to seek, and HCI is effectively riding this wave of research. The roles for IoT technologies in this space are rich and varied, as the authors discuss in Chapter “[From Social to Civic: Public Engagement with IoT in Places and Communities](#)”, from acting as a social catalyst to fostering awareness on social issues, from facilitating participation to collecting and spreading shared knowledge, up to an ultimate goal of empowering citizens by supporting the gathering of data, articulation of goals and advocacy of community efforts. There are, however, many challenges to address to make IoT in public places a sustainable and scalable tool for civic action, as the authors summarise in their ‘lessons learned’. The trade-offs between opportunities and costs are complex and difficult to navigate. Key aspects capable of sustaining engagement, such as providing hyperlocal contents and fostering collective ownership, mean that no one-size-fits-most solution exists, and rather interventions that work tend to be highly specific, participatory and embody shared knowledge and memories.

Together, these contributions shed new light on the numerous implications of designing Internet of Things devices, tools, platforms and applications. The social IoT encompasses all aspects of the IoT scenarios that escape a straightforward technical analysis. One way to appreciate the sociality of networked technologies such as the IoT is to resort to social networks theories to model their architectures and approach their study [8]. This, however, can only offer a partial explanation, as it does not consider the situatedness, in culture, in place and in society, of those technologies, nor can it capture the ways in which technologies, practices and even moral and ethical values are mutually constituted and continuously renegotiated. From the intimacy of the home to the public space and workplace, issues of agency,

engagement, reciprocity, privacy, respect and dignity will always emerge as novel technologies are embodied in social interaction.

This book is an attempt to reposition the debate around IoT technologies within a more complex account of its social, political and creative, as well as technical roots, in the hope to spark a more nuanced conversation, and ultimately, contribute to the design and creation of the Internet of Things people *really* want.

Brisbane, Australia

Alessandro Soro
Margot Brereton
Paul Roe

References

1. Ashton, K. (2009). That internet of things thing. *RFiD Journal*, 22(7), 97–114.
2. Bell, G., & Dourish, P. (2007). Yesterday's tomorrows: notes on ubiquitous computing's dominant vision. *Personal and Ubiquitous Computing*, 11(2): 133–143.
3. Da Xu, L., He, W., & Li, S. (2014). Internet of things in industries: A survey. *IEEE Transactions on Industrial Informatics*, 10(4): 2233–2243.
4. Soro, A., Ambe, A. H., & Brereton, M. (2017). Minding the gap: Reconciling human and technical perspectives on the IoT for healthy ageing. *Wireless Communications and Mobile Computing* in press.
5. Soro, A., Brereton, M., & Roe, P. (2015). The Messaging Kettle: It's IoTea Time. In *Proceedings of the 5th Decennial Aarhus Conference*, 57–59.
6. Soro, A., Brereton, M., Roe, P., Wyeth, P., Johnson, D., Ambe, A. H., Morrison, A., Bardzell, S., Leong, T. W., & Wendy Ju, W. (2017). Designing the Social Internet of Things. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, 617–623.
7. Kortuem, G., Kawsar, F., Fitton, D., & Sundramoorthy, V. (2010). Smart objects as building blocks for the internet of things. *Internet Computing*, 14(1): 44–51. <https://doi.org/10.1109/MIC.2009.143>.
8. Atzori L., Iera, A., Morabito, G., & Nitti, M. (2012). The Social Internet of Things (SIoT) – When social networks meet the Internet of Things: Concept, architecture and network characterization. *Computer Networks*, 56(16), 3594–3608. <https://doi.org/http://dx.doi.org/10.1016/j.comnet.2012.07.010>.

Acknowledgements

The Social Internet of Things workshops, where this work originated, and the editing of this book have been in part supported by the Australian Research Council, grant DP150104001 *Make and Connect: Enabling People to Connect through their Things*. Support received by chapter contributors is acknowledged at the end of each chapter when appropriate. We wish to thank all the participants of the Social Internet of Things workshops for their valuable feedback and for contributing ideas and insights that materialised in this book. We especially wish to thank the co-organisers of the CHI-2017 workshop where many of the chapters included in this book were initially conceived: Peta Wyeth, Daniel Johnson, Aloha Hufana Ambe, Ann Morrison, Shaowen Bardzell, Tuck W. Leong, Wendy Ju, Silvia Lindtner, Yvonne Rogers and Jacob Buur. We finally wish to thank all students and academics of the CHI discipline at Queensland University of Technology that inspire us every day.

Contents

Part I Social IoT Vision

Beautifying IoT: The Internet of Things as a Cultural Agenda	3
Jeffrey Bardzell, Shaowen Bardzell and Szu-Yu (Cyn) Liu	
The Internet of Places	23
John M. Carroll	
From the Internet of Things to an Internet of Practices	33
Thomas Ludwig, Peter Tolmie and Volkmar Pipek	

Part II Social IoT Interaction Design

The Needfinding Machine	51
Nikolas Martelaro and Wendy Ju	
Exploring Interaction Design for the Social Internet of Things	85
Donald Degraen	
Designing Places for Reflection	107
Maliheh Ghajargar, Mikael Wiberg and Erik Stolterman	

Part III Social IoT Applications

Sensing Home: Participatory Exploration of Smart Sensors in the Home	123
Arne Berger, Andreas Bischof, Sören Totzauer, Michael Storz, Kevin Lefevre and Albrecht Kurze	
Direct End-User Interaction with and Through IoT Devices	143
Markus Rittenbruch and Jared Donovan	

Engaging Children with Neurodevelopmental Disorder Through Multisensory Interactive Experiences in a Smart Space	167
Franca Garzotto, Mirko Gelsomini, Mattia Gianotti and Fabiano Riccardi	
From Social to Civic: Public Engagement with IoT in Places and Communities	185
Can Liu, Mara Balestrini and Giovanna Nunes Vilaza	

Contributors

Mara Balestrini Ideas For Change, Barcelona, Spain

Jeffrey Bardzell School of Informatics, Computing, and Engineering, Indiana University, Bloomington, USA

Shaowen Bardzell School of Informatics, Computing, and Engineering, Indiana University, Bloomington, USA

Arne Berger Media Informatics, Technische Universität Chemnitz, Chemnitz, Germany

Andreas Bischof Media Informatics, Technische Universität Chemnitz, Chemnitz, Germany

John M. Carroll Center for Human-Computer Interaction, College of Information Sciences and Technology, Pennsylvania State University, University Park, PA, USA

Donald Degraen Intel Visual Computing Institute—Saarland Informatics Campus, Saarbrücken, Germany

Jared Donovan QUT Design Lab, School of Design, Queensland University of Technology, Brisbane, Australia

Franca Garzotto Politecnico di Milano, Milan, Italy

Mirko Gelsomini Politecnico di Milano, Milan, Italy

Maliheh Ghajargar Politecnico di Torino, Turin, Italy

Mattia Gianotti Politecnico di Milano, Milan, Italy

Wendy Ju Cornell Tech, New York, NY, USA

Albrecht Kurze Media Informatics, Technische Universität Chemnitz, Chemnitz, Germany

Kevin Lefevre Media Informatics, Technische Universität Chemnitz, Chemnitz, Germany

Can Liu National University of Singapore, Singapore, Singapore; City University of Hong Kong, Hong Kong, China

Szu-Yu (Cyn) Liu School of Informatics, Computing, and Engineering, Indiana University, Bloomington, USA

Thomas Ludwig University of Siegen, Siegen, Germany

Nikolas Martelaro Stanford University, Stanford, CA, USA

Volkmar Pipek University of Siegen, Siegen, Germany

Fabiano Riccardi Politecnico di Milano, Milan, Italy

Markus Rittenbruch QUT Design Lab, School of Design, Queensland University of Technology, Brisbane, Australia

Erik Stolterman Indiana University, Bloomington, USA

Michael Storz Media Informatics, Technische Universität Chemnitz, Chemnitz, Germany

Peter Tolmie University of Siegen, Siegen, Germany

Sören Totzauer Media Informatics, Technische Universität Chemnitz, Chemnitz, Germany

Giovanna Nunes Vilaza University College London, London, UK

Mikael Wiberg Umeå University, Umeå, Sweden