Public Administration and Information Technology 30

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Beyond Smart and Connected Governments

Sensors and the Internet of Things in the Public Sector

Springer

Public Administration and Information Technology

Volume 30

Series Editor

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ISSN 2512-1812 ISSN 2512-1839 (electronic)
Public Administration and Information Technology
ISBN 978-3-030-37463-1 ISBN 978-3-030-37464-8 (eBook)
https://doi.org/10.1007/978-3-030-37464-8

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

To my Amorecita Nadia, who has shared with me a life full of love and precious moments
—J. Ramon Gil-Garcia

To my dear husband Manuel, with love
—Theresa Pardo

To Marcos, Hawa, and Carlos, the love of my life, and to my Mom and Dad, for being always there
—Mila Gasco-Hernandez

Foreword

During the last decades, information systems became increasingly interconnected. What started with the Internet has evolved into the Internet of Things (IoT), where sensors and actuators are interconnected to measure and control systems from coffee machines to smart cities. This goes along with the collection of more and more data using IoT devices resulting in real-time availability of data about temperature, geolocation, pollution, gas and water flows, force, acceleration, and traffic throughput. These types of data are used already in our daily life. My smart phone warns me if there is a traffic jam, and I have to leave earlier than usual. The daily life of citizens has undergone drastic change and is likely to undergo even more changes (Chatterjee et al. 2018). In a similar vein, government practice is also changing. IoT-generated data provides immense potential for improving our daily life and can be used by the public sector to create societal value. Such types of changes are already visible in evidence-based policy-making in which data collected by IoT is used to develop better policies based on factual data.

The editors of the book recognized the immense opportunity of IoT on our society. J. Ramon Gil-Garcia, Theresa A. Pardo, and Mila Gasco-Hernandez did a wonderful job in bringing together the most recent advances in this field by covering a range of aspects resulting in a multidisciplinary book covering a comprehensive range of topics. They show that IoT is not a standalone technology and needs to be integrated in public administration practice. The adoption and use of IoT is typically an interdisciplinary endeavor in which organization and technical knowledge need to come together.

The relevance of this book does not have to be explained further when looking at the immense possibilities offered by IoT. For instance, IoT is used in smart homes. When my family and I are coming home and it is too cold, my smart home will detect this and will start heating my place. Governments use traffic and pollution data to guide traffic in different ways on a real-time basis and use the same data for the planning of new roads and public infrastructure. IoT can have many benefits ranging from the technical to the strategic level (Brous and Janssen 2015); however, unlocking the value is not easy. The IoT can be used to collect more and more data which can be used by public decision-makers to acquire the necessary insights in a timely fashion. IoT-enabled capabilities in real-time sensing and responding can

spur digital transformation, serve the public interest, and create public value (Chatfield and Reddick forthcoming). To take advantage of IoT as a transformational technology, new organizational and administrative processes are needed, systems need to be adapted, or new systems need to be developed and organizations need to develop new capabilities. IoT can have a transformative effect which requires considerable changes to profit from this technology (Brous et al. forthcoming).

The book consists of two main parts. In the first part entitled "*Theory, Frameworks, and Concepts on Internet of Things (IoT) in the Public Sector,*" the foundations of IoT in government are discussed. A range of issues from participation to security are part of the foundations and should be covered to advance this field. Although many people talk about the IoT, actual use is often limited to smart cities. Collaboration between agencies can be viewed as a condition for success to advance the use of IoT in government (Chatfield and Reddick forthcoming). In the second part of this book entitled "*Applications, Cases, and Experiences of Internet of Things (IoT) in the Public Sector,*" all kinds of international experiences are presented which can be used as a source of inspiration and facilitate learning. There is a need to share practices and conduct comparative research to learn from each other.

Beyond smart government requires the connection of the data generated from IoT with Artificial Intelligence (AI), which in turn can help to intervene in the environment. Algorithms are becoming an integral part of these connected systems like autonomous cars, smart living environments, and smart energy applications for energy transition (Janssen and Kuk 2016). Within these systems, AI can be used for simple tasks like cleaning data to complex decision-making processes involving data from countless distributed sensors. The intelligence provided by systems enable better information sharing and cooperation resulting in improved user-experiences and personalization, higher levels of efficiency, and a reduction of costs. Connected systems integrate data, algorithms, people, processes, and systems to create, for example, connected cars, smart living, and smart energy applications.

IoT is a new topic that has not been discussed widely. In particular in government, this is an area in which research and comprehensive insight is lacking (Brous and Janssen 2015). In this regard, this book fills the void in literature by being the first comprehensive work in the field of IoT in government. This book contributes to unlocking the value of IoT and provides insight to avoid its risks of violating privacy and avoiding security breaches.

Given the increasing use of devices, the knowledge this book provides is a timely and very relevant contribution for organizations wanting to unlock the societal value of IoT and for researchers working in this field. This is an issue that many organizations struggle with and deserves attention. Collaboration is needed, and public organizations need to develop knowledge in this field. This book can help to raise our understanding on how the digital society is shaped.

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Marijn Janssen

Marijn Janssen is full Professor in ICT and Governance and head of the Information and Communications Technology research group of the Technology, Policy and Management Faculty of Delft University of Technology. He worked for the Ministry of Justice and was involved in large transformation projects. He was involved in EU-funded projects in the past (a.o. EGovRTD2020, eGovPoliNet, Engage, VRE4EIC, and OpenGovIntelligence), is co-editor-in-chief of Government Information Quarterly, associate editor of the International Journal of Electronic Business Research (IJEBR), Electronic Journal of e-Government (EJEG), International Journal of E-Government Research (IJEGR), is conference chair of IFIP EGOV-ePart-CeDEM conference series and is chairing mini-tracks at various digital government and information systems conferences. He was ranked as one of the leading e-government researchers in a survey in 2009, 2014, and 2016 and published over 450 refereed publications. He was ranked by Apolitical as one of the 100 most influential people in the Digital Government in 2018 (https://apolitical.co/lists/digital-government-world100). More information: www.tbm.tudelft.nl/marijnj.

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Acknowledgments

This book is definitively the result of the dedicated effort of many great people who worked together and apart to bring this volume to fruition. We take this opportunity to express our sincere and deep regards and appreciation to all of those who helped and supported us in the conception and completion of this work. A special thank you to all the authors for sharing their knowledge through this editorial project and their interest in the use of sensors and the Internet of Things (IoT) in the Public Sector. This volume would not have been possible without the hard work and collegiality of authors, reviewers, the previous series editor, Christopher Reddick, the new series editor, Manuel Pedro Rodriguez Bolivar, and the staff at Springer. A special thank you to all the reviewers who not only gave their time and effort, but also shared their knowledge through very useful and constructive comments that enhanced the book's overall quality and contribution to the field.

From the staff at Springer, we would like to particularly mention the dedication and commitment of Lorraine Klimowich during the entire editorial process. We always received support and useful guidance from her. We also want to thank Ana Catarrivas, our editorial assistant, whose dedication and diligent efforts have been instrumental for the completion of this book. We are also grateful to CTG UAlbany, formerly the Center for Technology in Government, and the Rockefeller College of Public Affairs and Policy, University at Albany, State University of New York, from which we have received strong institutional support and great encouragement and motivation from colleagues and friends.

Finally, we want to send love and gratitude to our families. They have tirelessly encouraged us and wholeheartedly supported our academic endeavors.

J. Ramon Gil-Garcia
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Contents

About the Editors

J. Ramon Gil-Garcia is an Associate Professor of Public Administration and Policy and the Research Director of the Center for Technology in Government, University at Albany, State University of New York (SUNY). Dr. Gil-Garcia is a member of the Mexican Academy of Sciences and of the Mexican National System of Researchers as Researcher Level III, which is the highest distinction a researcher can obtain before becoming Researcher Emeritus as a result of a lifelong career of research contributions. In 2009, he was considered the most prolific author in the field of digital government research worldwide, and in 2013 he was selected for the Research Award, which is "the highest distinction given annually by the Mexican Academy of Sciences to outstanding young researchers." More recently, Dr. Gil-Garcia was named one of the "World's 100 Most Influential People in Digital Government in 2018" by Apolitical, which is a nonprofit organization based in London in the United Kingdom. Currently, he is also a professor of the Business School at Universidad de las Américas Puebla in Mexico, a Faculty Affiliate at the National Center for Digital Government, University of Massachusetts Amherst, and an Affiliated Faculty member of the Information Science Doctorate Program at the College of Engineering and Applied Sciences, University at Albany. Dr. Gil-Garcia is the author or co-author of articles in prestigious international journals in Public Administration, Information Systems, and Digital Government and some of his publications are among the most cited in the field of digital government research worldwide. His research interests include collaborative electronic government, inter-organizational information integration, smart cities and smart governments, adoption and implementation of emergent technologies, information technologies and organizations, information technologies and education, digital divide policies, new public management, public policy evaluation, and multi-method research approaches. Dr. Gil-Garcia has extensive teaching experience and has collaborated with 11 universities, including departments of Public Administration, Political Science, Social Science, Information Studies, and Management Information Systems. Dr. Gil-Garcia also has many years of experience as a consultant for federal, state, and local government agencies.

Theresa A. Pardo is Director of CTG UAlbany, an applied research institute at the University at Albany, State University of New York, where she is also a full research professor in Rockefeller College of Public Affairs and Policy. CTG UAlbany works closely with multi-sector and multidisciplinary teams from the USA and around the world to carry out applied research and problem-solving projects focused on the intersections of policy, management, and technology in the governmental context. Dr. Pardo serves as OpenNY Adviser to New York State's Governor Andrew Cuomo and is Chair of the U.S. Environmental Protection Agency's National Advisory Committee. She serves as a member of the User Working Group of the NASA Socioeconomic Data and Applications Center (SEDAC), the Business and Operations Advisory Committee of the U.S. National Science Foundation, and the Steering Committee of the U.S. National Science Foundation funded North East Big Data Innovation Hub. Dr. Pardo is founder of the Smart Cities, Smart Government Research-Practice Global Consortium, and a Past-President of the Digital Government Society. In 2018, Dr. Pardo was named as one of the Top 100 Influencers in Digital Government globally. She is also a recipient of *Government Technology Magazine'*s Top 25 Doers, Drivers, and Dreamers Award which recognizes individuals throughout the USA who exemplify transformative use of technology that is improving the way government does business and serves its citizens. Dr. Pardo is a recipient of the University at Albany's Distinguished Alumni Award, the University at Albany's Excellence in Teaching Award, and the Rockefeller College Distinguished Service Award. Dr. Pardo holds a Ph.D. in Information Science from the University at Albany, SUNY.

Mila Gasco-Hernandez holds an MBA and a Ph D in Public Policy Evaluation (Award Enric Prat de la Riba granted to the best Ph D thesis on public management and administration, given by the School of Public Administration of Catalonia in Barcelona, Spain). She is the Associate Research Director of the Center for Technology in Government as well as a Research Associate Professor at the Rockefeller College of Public Affairs and Policy, both at the University at Albany—SUNY. Before joining SUNY, Dr. Gasco-Hernandez served as a senior researcher at the Institute of Governance and Public Management (currently known as ESADEgov—Center for Public Governance) and the Institute of Innovation and Knowledge Management, both at ESADE Business and Law School in Spain. Previous to that, she was a senior analyst at the International Institute on Governance of Catalonia and a professor in Rovira i Virgili University and Pompeu Fabra University, both in Spain.

Mila Gasco-Hernandez has considerable consulting experience on the information and knowledge society as well. In this respect, she has worked for a wide variety of organizations such as the United Nations Development Programme, the Mayor's Office in Valencia (Venezuela), the Spanish Agency for International Development Cooperation, the City Council and the Provincial Council of Barcelona, the International Institute for Democracy and Electoral Assistance, the Latin American Centre on Management for Development (for whom she co-developed the Ibero-American Interoperability Framework), the World

e-Governments Organization of Cities and Local Governments (she was the leading judge for the WeGo Awards), the Inter-American Development Bank, or Google.

Her areas of research are mainly related to information and technology in government and, among others, they include electronic and open government, e-governance, public sector innovation, smart cities, and public policy evaluation.

Chapter Summaries

Chapter 1: The Internet of Things (IoT) is the newest example that fills the gap between cyber world and physical world. The Internet of Things is poised to revolutionize state and local governments. The transformational journey of IoT promises the power to change the world in such a way that people will get closer to their fully integrated and smart surroundings for better management of energy, health, transportation, and life resources. This chapter aims to introduce the presence and relevance of the study of the Internet of Things from a government and public policy perspective.

Chapter 2: The IoT is a revolutionary development for both society and governments. In this chapter, opportunities and threats of the IoT are discussed. Linking technological, societal, economic, and policy-oriented aspects of the IoT, this chapter introduces a conceptual framework to map and analyze the factors or obstacles that arise in addressing IoT opportunities and threats, and possible government measures to mitigate these factors. By adopting a broad view and paying attention to the relations between different factors, this chapter shows that there is no one-size-fits-all solution for IoT-related issues, as different problems and solutions are interdependent and require a coherent government approach.

Chapter 3: Smart cities seek to address public issues via digital connected solutions on the basis of a multi-stakeholder, municipally based partnership. This urban model includes using Internet of Things (IoT) facilities to deliver public services. However, the implementation of public service delivery and use through IoT in smart cities is frequently fragmented, hindering a sustainable urban development. Citizens remain unaware of various single tools developed without their participation. Security issues also prevent citizens from using IoT facilities in smart cities. The objective of this chapter is to explain the development of a participatory governance approach, aiming to establish a sustainable development path for the design and implementation of public services for work and mobility, delivered through IoT in smart cities. Progressing from key issues extracted from existing research about public service delivery using IoT in smart cities, the approach adopts a socio-technical, processual methodology combining several social research methods as well

as visualization and game simulation techniques. The chapter concludes with a short discussion about the application of this participatory framework in the ongoing design and evaluation of sustainable public service delivery using IoT in smart cities.

Chapter 4: This chapter reviews the expanding role of the Internet of Things (IoT) in our lives as well as the security concerns of IoT. While IoT has expanded enormously in recent years both in the private and public sectors where it has enhanced the quality of life, it has also created potential security risks for users in various ways, such as in enabling unauthorized access and misuse of personal information, facilitating attacks on other systems, and creating safety risks. Even though these risks were already common in cyberspace contexts, the introduction of IoT has increased these risks given its role in expanding the Internet and its connections to every aspect of our daily lives. This chapter will provide a systematic review of the current literature of IoT in order to identify IoT security challenges, and to offer recommendations for responding to these challenges. As a result of our study, we identified pervasiveness, privacy, and vulnerability as main challenges that are discussed in the literature. In this research, we also compiled some recommendations such as encryption, cryptology, authentication, authorization, and advanced security frameworks, schemes, and protocols to respond current security challenges in the IoT. Policy recommendations are also discussed to give ideas to policymakers about IoT security.

Chapter 5: Blockchain technology is attracting the interest of professionals and academics across a variety of disciplines, including the interdisciplinary field of Digital Government. Such technology has the potential to transform the public sector by providing innovative ways to secure data and avoid tampering. However, few studies have theorized on experimental applications of such technology and how it could be applied to data management practices in data-rich environments such as the Internet of Things (IoT) applications in smart cities. This chapter proposes a workflow diagram for technical experiments that explore how blockchain technology can protect the integrity of data from sensors in a context where IoT is the underpinning infrastructure. This endeavor helps to contextualize this emerging technology and sheds light on opportunities, risks, and challenges of using blockchain technology in environments where intensive data collection is the norm. Contributions include a framework on data management for IoT that can be of special value to local governments that are considering blockchain as instrumental in engaging in or enhancing data-driven operations.

Chapter 6: This chapter explores implementation challenges as opportunities for moving beyond smart and connected governments by focusing on awareness in relation to sensing, sensors, and the Internet of Things (IoT) in the public sector in the context of smart cities. A review of the research literature for smart city implementations is conducted from multiple perspectives highlighting a range of issues and challenges for the public sector. The theoretical framework for this chapter uses the construct of awareness in relation to the key smart city characteristics of adaptability,

complexity, innovation, and readiness. The research design for this work utilizes a single case study approach to explore evolving understandings of smart city implementations in contemporary urban environments. Multiple methods of data collection are used including survey and interview while content analysis is used in the iterative analysis of data. Data were collected and analyzed from diverse individuals in multiple small- to medium- to large-sized cities, mostly in Canada and extending to other countries (e.g., Israel). This work makes several contributions by providing: (a) an expanded way of looking at IT implementation in the public sector for twenty-first century urban environments encompassing sensing, sensors, and the IoT; (b) understandings of IT implementation challenges as opportunities in the public sector for more responsive and aware solution-making; and (c) a conceptual framework for more dynamic notions of implementation in the public sector, as in, ambient implementation. This chapter advances an awareness-based explanatory model for ambient implementation of use to the public sector in smart cities.

Chapter 7: The Internet of Things is being actively introduced in Russian public governance for inspection and oversight. In this chapter, based an analysis of IoT policy, legal acts, secondary statistical data, and the authors' own involvement in testing IoT technologies, we formulate cases and use them as a basis for an IoT classification oriented to the needs of government agencies. The spheres of application we consider are transport, justice, retail, and manufacturing. The case we study in greatest detail is that of the fur industry. We apply the method of cost-benefit analysis and examine the costs of using IoT in public governance to regulate the turnover of fur goods as well as the benefits for key stakeholders (government, society, business). We identify barriers that prevent IoT technology from being used effectively and describe the effects of implementing IoT in the fur industry and other areas in which IoT is used for inspection and oversight.

Chapter 8: Since 2014, the question of the implementation of the Internet of Things has been crucial in France. Public authorities have created arenas where digital entrepreneurs and politicians can discuss the evolution of the Internet of Things. In January 2017, the National Assembly published a report on the economic and social consequences of the adaptation of the Internet of Things. This chapter analyzes the political discourse that gives legitimacy to the implementation of the Internet of Things in France. The digital entrepreneurs are the privileged actors of this implementation, their social recognition by the French Parliament and the labeling campaigns (French Tech) reinforce the myth of technological innovation. The field of the critical analysis of discourse is mobilized to evaluate the spread of this new myth in France and the analysis of the legitimization of the digital entrepreneurs. This case study reveals how European countries tackle new digital policies in order to control the evolution of the Internet of Things and the field of Artificial Intelligence.

Chapter 9: In its simplest form, smart government can be understood as the combination of new technologies and organizational innovation strategies to further modernize the public sector. Within this development, the Internet of Things (IoT) often forms a key technological foundation, offering government authorities new

possibilities for interaction with citizens and local communities. On one hand, citizens can indirectly participate in governmental services' value creation by using public infrastructure or (un)knowingly sharing their data with the community. On the other hand, smart government initiatives may rely more intensively on citizens' active participation to improve public service delivery, increase trust in government actions, and strengthen community sentiment. In this chapter, we discuss active and passive participation scenarios of smart government initiatives and explain how sensor-based systems may enhance citizens' opportunities to participate in local governance. We present two practical cases from Switzerland demonstrating these two citizen involvement modes. We argue that active and passive participation of citizens and other stakeholders play key role in generating necessary data for algorithmic decision-making to enable personalized interaction and real-time control of infrastructure in the future. We close with a discussion of the possibilities and boundaries of the IoT in the public sector and their possible influences on citizens' private lives and policy-making.

Part I
Theory, Frameworks, and Concepts on Internet of Things (IoT) in the Public Sector

Internet of Things and the Public Sector

J. Ramon Gil-Garcia, Theresa A. Pardo, and Mila Gasco-Hernandez

Abstract The Internet of Things (IoT) is one of the most recent examples of a technology that has the potential to bridge the cyber world and the physical world. The IoT can be understood as the integration of a great number of small devices (including many types of sensors, which are components capable of detecting changes in its environment and converting this change into an electrical signal) into a network that shares and integrates their data, which can be used for real-time decision-making. The transformational power of the IoT promises to change the world by fully integrating people into their surroundings for better management of energy, health, transportation, and life resources. In the public sector, the IoT has the potential to revolutionize federal, state, and local government programs and services, particularly in domains in which the physical infrastructure or the natural world are key elements of those programs. This chapter conceptualizes the IoT, outlines some potential benefits generally and in the public sector, and presents some of the challenges to adoption and use of the IoT. The chapter closes with an overview of the subsequent book chapters.

Keywords Internet of things · IoT · Public sector · Public policy · Government · Sensors

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J. R. Gil-Garcia et al. (eds.), *Beyond Smart and Connected Governments*,
Public Administration and Information Technology 30,
https://doi.org/10.1007/978-3-030-37464-8_1

Introduction

The Internet of Things (IoT) is one of the most recent examples of a technology that has the potential to bridge the cyber world and the physical world. The IoT could be understood as the integration of a great number of small devices (including many types of sensors, which are components capable of detecting changes in their environment and converting those changes into an electrical signal) into a network that shares and integrates their data, which can be used for real-time decision-making. Since fiscal year 2011, federal government spending on the IoT has grown at a compound annual rate of 10 percent (Perera et al. 2014). Growth figures such as those presented during the OECD's 2014 Technology Foresight Forum provide further evidence of interest in the IoT: "The number of connected devices in households in OECD countries is expected to be 14 billion by 2022, up from around 1.4 billion in 2012, or to put it differently, from 10 connected devices in a household with two teenagers to 50 in ten years' time" (OECD, Technology Foresight Forum, 2014). It is estimated that by 2020, there will be 50–100 billion devices connected to the Internet (Sedrati and Mezrioui 2018). The vision of the IoT is to allow "things" to be connected anytime, anyplace, with anything and anyone (Perera et al. 2014). In general terms, the IoT refers to a network of interconnected everyday objects. It comprises billions of connected "things" or devices that can sense, communicate, compute, and potentially actuate. These objects have intelligence, multimodal interfaces, and physical/virtual identities and attributes (Perera et al. 2014).

Maximizing the potential of the IoT requires understanding of the technology itself, as well as a consideration of that technology within potential use contexts (Werthmuller 2016). Understanding the nature of the IoT and its potential to create value across the sectors is still in its nascent stages. However, in recent years, the IOT has gained much attention from researchers and practitioners from around the world (Xia et al. 2012). For instance, Erfanmanesh and Abrizah (2018) found that there has been a continuous increase in the number of scholarly publications about the IoT per year over the period between 2011 and 2016, with a 6.7-fold rise in the number of publications and the highest share of research output (4989) published in 2016. Research on the IoT has largely focused around single application domains or single technologies (Miorandi et al. 2012).

This book makes a unique contribution to efforts to understand the IoT and its value-creation potential in the public sector, specifically through an integrative examination of the relevant literature and presentation of a set of studies that introduce concepts and frameworks for IoT use, present methodologies for building understanding of the IOT, and provide case studies.

This chapter introduces the concept of the IoT by highlighting definitional elements from the literature, implications for use, and potential applications in the public sector context. The chapter is organized in seven sections, including the foregoing introduction. Section "Conceptualizing the Internet of Things (IoT)" presents some definitions of the IoT from the academic literature. Section "Potential Benefits of IoT" includes some of the potential benefits of the Internet of Things. Section "IoT and the Public Sector" describes and explains how the IoT could affect the

public sector. Section "Challenges to Creating Value with the IoT" discuss some of the expected challenges to the use of Internet of Things. Section "A Book on the IoT from a Public Sector Perspective" presents brief summaries of the chapters included in this book and section "Concluding Remarks" offers some final comments and ideas for future research about this topic.

Conceptualizing the Internet of Things (IoT)

The phrase "the Internet of Things" is syntactically composed of two terms. The first one pushes towards a network-oriented vision, while the second one moves the focus onto generic "objects" to be integrated into a common framework (Atzori et al. 2010). Semantically speaking, the "Internet of Things" means "a world-wide network of interconnected objects uniquely addressable, based on standard communication protocols" (Infso 2008), which implies a huge number of (heterogeneous) objects involved in the process. At its inception, the concept was related to the use of emerging sensor technologies and radio frequency identification (Sundmaeker et al. 2010).

The term "the Internet of Things (IoT)" seems to act as an umbrella concept that covers various features such as the extension of the Internet, the web as a physical realm, deployment of extensive embedded distributed devices, and actuation abilities (Miorandi et al. 2012). Some call it the "Internet of everything," defined as "people, process, data and things to make networked connections more relevant and valuable than ever before, turning information into actions that create new capabilities, richer experiences, and unprecedented economic opportunity for businesses, individuals, and countries" (Hatem et al. 2016).

Today, many mobile devices have built-in sensors (e.g., a GPS sensor or an accelerometer). These sensors can be useful for tasks such as traffic monitoring. The data collected can be analyzed using a range of techniques, and used for predictions, pattern recognition, forecasting, visualizations, and decision support (Johannessen and Berntzen 2016).

In the vision of the IoT, an increasing number of embedded devices of all sorts are capable of communicating and sharing data over the Internet (Zeng et al. 2011). The IoT will increase the ubiquity of the Internet by integrating every object for interaction via embedded systems, leading to a highly distributed network of devices communicating with human beings as well as other devices. The condition required to make something an IoT object is that it contains a sensor/actuator that can communicate and support the three pillars of the interconnection of smart objects: identification, communication, and interaction (Sedrati and Mezrioui 2018; Bilal 2017).

From a research perspective it is more difficult to understand what exactly the IoT is and what the technical, economic, and social implications of full deployment of the IoT may be (Atzori et al. 2010). For some authors, the IoT represents the next evolution of the Internet; it is increasing the universality of the Internet by integrating every object for interaction via embedded systems, creating a highly distributed