

Preface

As the reader may guess, ever since we decided to edit this book, our main objective is to invite people to delve into the Internet of Everything (IoE). The IoE makes the Internet connections more valuable than ever before, converting information into wise actions that create unprecedented capabilities, richer experiences, and economic opportunities to all players in this market. The truth is that the Internet is evolving at a remarkable rate to the IoE, many times in ways difficult to imagine in recent years. In its way, many phases were overpassed, from the digitizing access to information (connectivity), the digitization of business processes (e.g., e-commerce), the digitization of interactions (e.g., social or cloud), to the digitised world connecting people, data, process and things (the IoE).

Many overlapping fields of research cooperate to carry out this IoE venture. Artificial intelligence, computer science, informatics, electronics, mathematics, management, or social sciences are just a few examples. This vastness of fields brought together a set of international experts on the design, evaluation, implementation and use of innovative technologies which include computer scientists, electrical engineers, security experts, data scientists, business intelligence analysts, and managers.

As this book delves in to the theory and applications of the IoE, many chapters explore machine learning, Internet of Things (IoT), software, hardware, smart homes and cities, human computer interaction, management or economics sciences, touristic added value etc. On its grounds, the book emphasizes trending research fields, for which major companies (such as Microsoft, Google, Amazon, or Apple), technology leaders (e.g., Elon Musk or Mark Zuckerberg), universities, research centers, and media are constantly addressing in their speeches. Those entities put this book in an environment with rapid growth, a market of billions of dollars, and potentially billions of users.

The book's target include academicians, researchers, advanced-level students, technology developers, policy makers or simple curious, that are interested in the new trends of IoE. The book can help professors, engineers, policy makers, and investigators in the teaching and in the improvements of their systems and applications. In addition, for professors and professionals in IoE engineering, the book will help them to improve their knowledge about the contemporary theories, technologies and tools available, and in this way be more demanding and capable of improving their products or teaching.

IoE general concepts, practical application, platforms, physics/electronic and security are addressed in the present book being organized as follows. Chapter 1, "Internet of Everything: A Unifying Framework Beyond Internet of Things," analyses the IoE landscape according to various application domains, giving for each an up-to-date account of the state-of-the-art in related fields. The authors also discuss a wide spectrum of challenges and future research directions, including ubiquitous connectivity, security, big data, etc., which are common to many application domains and penetrate into the IoE effort in general. Machine Learning, applied in the last decades in a vast research fields (e.g., image recognition, speech

Preface

recognition, medical diagnosis, recommendation engines, surveillance, autonomous vehicles or personal assistants), has also the potential to improve the IoE research by adding value to the sector's productivity chain. In that sense, the second chapter, "Application of Machine Learning Algorithms to the IoE," presents a survey on the application of machine learning algorithms to the Internet of Everything. The survey is particularly interested in computational frameworks for the development of intelligent system, including different types of storage and applications of machine learning. An example of a system, which includes the data acquisition device, the data communication and storage, and a machine learning application is also included in the chapter.

The number of IoE applications and variety is huge, as stressed in some of the following chapters. One of the fields of application of IoE includes Energy Management. In this area, Chapter 3, "IoE-Based Control and Monitoring of Electrical Grids: A Smart Grid Perspective," presents the implementation of an IoT based system for microgrids, that supports the development of an Energy Management System (EMS). These EMS enable not only the monitoring, but also the optimized control of microgrids that integrate renewable energy sources. After presenting and comparing the state-of-the-art solutions in wireless sensor networks that can be used to build such an EMS, the authors describe the implementation of a set of LoRaWAN devices that can be used to support the development of the EMS. In the natural environment area, managing and delivering water involves careful planning to ensure its quality and security, more easily accomplishable using the IoE. The fourth chapter, "Water Management for Rural Environments and IoT," presents a work being developed in the management of water quality monitoring systems. The discussion includes a general architecture for water quality monitoring systems, computer security (namely the one related to the blockchain technology), web services and data transmission technology, micro web frameworks, and cloud IoT services. Another topic of great relevance given the ageing of the world population and the need to maintain the people's independence as long as possible is addressed in the next chapter, "Ambient Assisted Living and Internet of Things." The chapter presents a study on ambient assisted living (AAL) and IoT with particular focus on their applications for enhancing indoor living environments and occupational health. With its main focus on smart homes, wearables sensors and health systems, the chapter provides a transversal vision of IoT and AAL technologies.

The computational development of IoE platforms requires qualified workers and many working hours to be developed. Those platforms are many times similar in their core meaning that their usage can be somehow standardized or common. The next chapters present two solutions. Chapter 6, "Cloud-Based IoT Platform: Challenges and Applied Solutions," introduces a cloud-based platform for the IoT concerned with data storage, device management, data processing and the integration with external systems, while providing high level of security and scaling. The platform's objective is to accelerate and simplify the development of IoT projects by lowering the entry barrier and offloading some of the burden off developers, giving them more time to focus on other aspects such as hardware and applications. Implementation issues in the functional and design perspective are also discussed. Chapter 7, "Challenges and Trends in Home Automation: Addressing the Interoperability Problem With the Open-Source Platform openHAB," analyses current trends and challenges in home automations, by proposing a way to deal with the interoperability problem by means of the open-source platform openHAB. The system is based on the concept of a Home Automation Bus, an idea that enables the separation of the physical and the functional view of any device, allowing to create a technology-agnostic environment, which is perfect for addressing the interoperability problem.

As mentioned before, the concept of IoE involves an intelligent connection of people, processes, data and things. The following chapter, “Mixing Different Realities in a Single Shared Space: Analysis of Mixed-Platform Collaborative Shared Spaces,” aims to analyze the benefits and features of Augmented, Virtual and Mixed Reality systems, reviewing related works and proposing a series of features for the design of effective mixed-platform collaborative shared spaces. In particular, the authors propose five setups with different levels of immersion/interaction. These systems were analyzed with respect to navigation, user representation, interaction and annotation, among others, including some applications proposed within the given framework. In addition, the constantly increasing potential of IoT enabled devices and the establishment of cloud technologies as an enabling framework which can help address damage of Cultural Heritage (CH) artefacts. In Chapter 9, “An IoE Architecture for the Preservation of the Cultural Heritage: The STORM Use Case,” the authors present an IoE architecture, empowered by an easy to deploy cloud framework for the protection of CH. One Particular use cases from CH sites are presented. All this information (and more as can be seen in other chapters) is causing our ability to collect massive amounts of data for comprehensive analysis to achieve a level of understanding not previously possible. Since the IoE has such a strong focus on collecting and analyzing data using smart sensor enabled devices, eye tracking data is a perfect tool to retrieve information. Chapter 10, “Internet of Everything (IoE): Eye Tracking Data Analysis,” focuses on eye tracking and other biometric sensor based data that can be collected and analyzed locally in real time through fog/edge computing or cloud based big data analytics.

IoE implementation is not possible without the hardware and the new technologies integrated circuits especially designed for sensors and ultra-low-power circuits. In “Ultra-Low-Power Strategy for Reliable IoE Nanoscale Integrated Circuits,” an Adaptive Frequency and Voltage Scaling technique is used, based on aging-aware global and local performance sensors, to implement drastic power savings in circuits and cyber-physical systems for IoE. By working at subthreshold supply voltages and controlling the supply voltage according with the available environmental and working conditions, the proposed technique allows circuits to be dynamically optimized, during their lifetime, while prevents error occurrence.

The last two chapters focus in security in the field of IoE. “Security Awareness in the Internet of Everything” presents fictious stories to stress the problems and potential risks about security in IoE. One contributing factor of this chapter is the level of security education of users of IoE systems. Another factor concerns security-awareness of the engineers developing cyber-physical systems. Authors interviewed developers, did surveys and workshops showing that this and other stories can become a reality. Authors did practical evaluation looking at the connectivity of commercial vehicles, as representative for internet-of-things applications, and shared thoughts towards attacking not connected society-critical facilities. The chapter ends with countermeasures for dealing with cyber-security threats, highlighting the role of authorities. With the growing number of wireless devices in the Internet of Things, maintenance and management of these devices has become a key issue. In particular, the ability to wirelessly update devices is a must in order to fix security issues and software bugs, or to extend firmware functionality. In this field, Chapter 13, “Securing Over-the-Air Code Updates in Wireless Sensor Networks,” presents an overview of various over-the-air code update techniques for WSNs and their security flaws along with some existing attacks and possible countermeasures. It also discusses which attacks can be used more easily with the code update functionality and gives a guideline to choose the right combination of countermeasures.

Preface

As a conclusion, the book brings together a comprehensive collection of research trends on the edge field of IoE from a set of international experts on the theoretical, design, evaluation, implementation and use of innovative technologies on the fields. This allows to join in a single document many points of view that usually are not integrated, as these subjects are scattered in many articles (e.g., proceedings, journals and Internet). Furthermore, many chapters are focused on applications, making it more compelling for a majority of potential readers. Scholars and/or practitioners of fields such as ML, IoT, management, engineering systems, among others can reference it as an information source. Each chapter brought state of the art research, complemented with applications, most of them not yet developed and published, except by the authors.

We hope you will enjoy reading *Harnessing the Internet of Everything (IoE) for Accelerated Innovation Opportunities*.

Pedro J. S. Cardoso
University of Algarve, Portugal

Jânio Monteiro
University of Algarve, Portugal

Jorge Semião
University of Algarve, Portugal

João M. F. Rodrigues
University of Algarve, Portugal