

Green RFID Systems

Combining cutting-edge technologies and techniques with existing approaches, this book equips you with the tools and knowledge needed to develop new energy-efficient and environmentally friendly RFID (radio frequency identification) systems.

As well as covering RFID basics, a wide range of new technologies is discussed, including biodegradable and recyclable material use, energy scavenging, passive and chipless architectures, RFID passive sensors, networked RFID and RFID sensors, organic electronic devices, textile electronics, and distributed and wide area electronics. Providing a clear description of how RFID technology can enable the evolution of the Internet of Things, the book guides you down the path to facing new challenges as we move towards ubiquitous sensing for smart environments and a networked society. This is an ideal guide for researchers in academia and industry, technical managers, and graduate students in RF and wireless communications.

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Cambridge University Press
978-1-107-03040-4 - Green RFID Systems
Edited by Luca Roselli
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UNIVERSITY PRESS

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CAMBRIDGE
UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning, and research at the highest international levels of excellence.

www.cambridge.org

Information on this title: www.cambridge.org/9781107030404

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First published 2014

Printed in the United Kingdom by Clays, St Ives plc

A catalog record for this publication is available from the British Library

ISBN 978-1-107-03040-4 Hardback

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Introduction

Since a beginning in the late forties, the development of solid state electronics has been characterized by relentless progress toward miniaturization and concentration of functionalities, mainly computational operations, in an ever smaller volume. This behavior was first expressed theoretically by Gordon Moore in 1964 when he formulated his greatly renowned “Moore’s Law.”

In the last decade we have experienced a fairly new scenario: on the one hand, technology development has introduced new concepts and materials. Beyond conventional semiconductors (group IV and III-V elements), carbon-based materials such as carbon nanotubes (CNT) and graphene, along with organic semiconductors, have been investigated. Focusing on substrates and supports, conventional materials (ceramics, Teflon-based, glass fiber, and so on) come alongside others that are new, low cost, easily producible in large areas, and eco-friendly. Material science, to this extent, is in its infancy, nevertheless some materials can be cited already: paper, bioplastics, PET, and likely many others in the near future. On the other hand, traditional electronics, still developing according to Moore’s Law in the miniaturization direction, often referred to as “More Moore axis,” is experiencing this inherent saturation. Incidentally, Moore himself, in a famous interview in 2004, on the occasion of the celebration of the forty years since the Moore’s Law formulation, said, referring to it: “It can’t continue forever. The nature of exponentials is that you push them out and eventually disaster happens.” He was the only one having the credibility to say that, at that time. I wish to expand a bit on this: it is a matter of fact that the ICT policy of the industrialized world, in supporting societal development and steering investments, is addressing new challenges. From the technological side, this trend can be summarized by the well known expression “More than Moore.” This emphatic expression actually means that beside investments to foster miniaturization (More Moore), technology developments have to be directed towards adding more functionalities to electronic systems. It is worth noting that this new direction is not an alternative to the previous one, instead it stimulates new investigations and new ways to exploit all the technologies developed and being developed, ultimately enabling new solutions for societal challenges and needs.

At this point I wish to take this concept to the extreme: we are assisting, combining More Moore and More than Moore approaches, in a large development of multi-functional, heterogeneous, highly miniaturized electronic systems: why not extend these systems to distributed architectures? Once we have multi-functional miniaturized systems, why don’t we incorporate them in everyday objects? We are clearly entering the

world of Internet of Things (IoT); a world where objects in general (things, animals, humans) can host electronic devices, collect information, and process and react to this information doing something by themselves or just send information to the internet for further decision taking.

Is this a precise vision of the future? We cannot say “precise,” but certainly evolution is also in this direction.

Now the question is: how can scientists and technicians foster this evolving scenario? If we refer to what can be seen as a stabilized “networked society,” where information is automatically collected by “objects” that can react by themselves (smart objects) or transfer information to humans via the internet, we have to face mainly two big challenges: first, it is impossible to connect all the objects to the grid or put batteries that last for life in them; second, we have to avoid producing long lasting apparatuses that outlive their host objects, thus causing pollution. Internet of Things is a very multidisciplinary evolution area, but whatever the developments towards the Internet of Things, it will need technological platforms that must be eco-friendly and energetically autonomous – in one word “green.”

Keeping on thinking about the future networked society and understanding that the adopted technologies must be “green,” the next question is: given that the technological platform must be green, what are the architectures and protocols suitable to support new distributed functionalities?

Without lack of generality, a fascinating possibility enabled by the availability of distributed smart objects consists of collecting information in a distributed instead of a concentrated way. Mapping of a parameter over a mesh, the granularity of which depends on the spatial distribution of smart objects, is straightforward. The problem is that these objects have to collect information and transfer it to the network autonomously. One of the most suitable means to satisfy these requirements is the RFID concept. RFID, in fact, is a way to get information from a tag by means of an interrogation protocol between a tag and a reader.

It is not the intention to extend the RFID description in this introduction, but it is just worth underlining that, in principle, this communication approach allows information to be gathered and transferred to a network, without either physical contact to the tagged object or power supplying it via a connection to the grid: thus objects become smart, but remain autonomous.

The main objective of this book is just to give an overview of a basic technology, foreseeable as of now, to face the development of distributed apparatuses for applications in the Internet of Things in line with the vision of a networked society.

To meet this objective the book is structured as follows:

First a historical overview of the development of RFID systems as well as a recap of RFID working principles is given in Chapters 1 and 2.

Second, a description of the main challenges posed by tagging objects in the context of distributed, RFID-based solutions, is given in Chapters 3 and 4, namely: energy harvesting, required to provide objects’ autonomy, and RFID sensor development to provide the functionality of getting information from the environment.

Third, the book enters the area of unconventional RFID systems devoted to new distributed scenarios. Chapters 5 and 6 refer to unconventional RFID applications and how to connect RFID systems to a network, respectively.

Fourth, materials and related technologies for the realization of green RFID systems to be used within these new massively distributed applications are described in Chapters 7 and 8.

Fifth, in Chapter 9, chipless architecture has been introduced to provide a means to push to the extreme the possibility of realizing ultra-low cost, low power tags for sensing objects.

Sixth, eventually in Chapter 10, examples of new materials, specifically textile ones, are given to provide new solutions in all those applications directly involving humans.