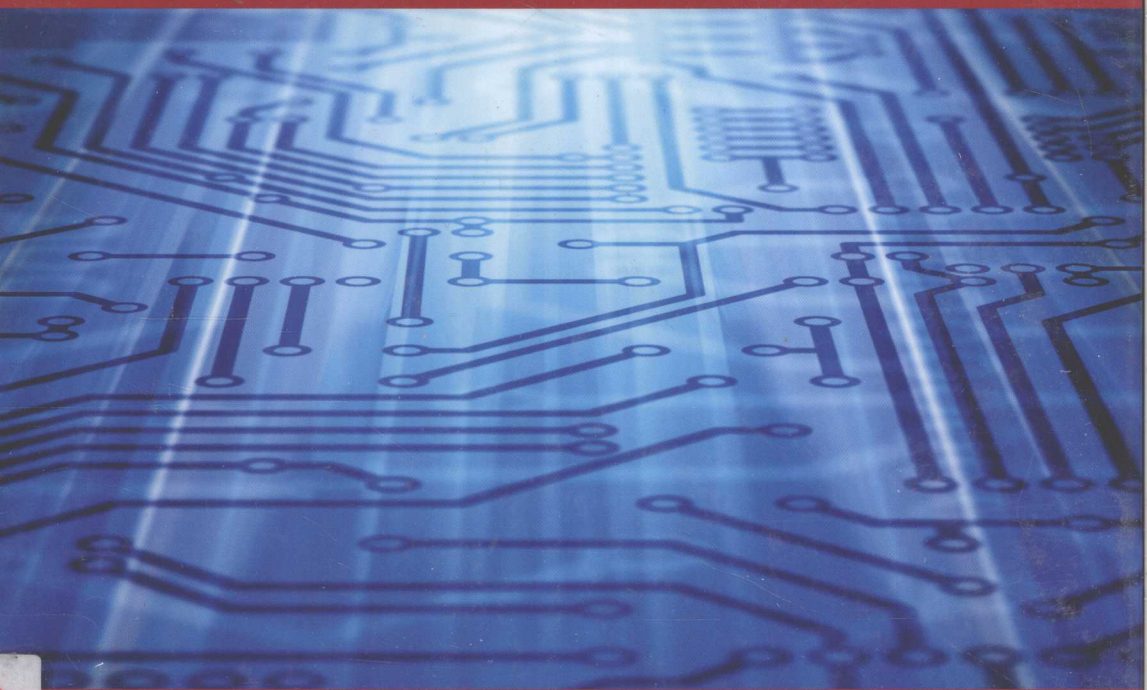
RFID and the Internet of Things

Edited by Hervé Chabanne
Pascal Urien and Jean-Ferdinand Susini



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Foreword

The RFID (*Radio Frequency Identification*) technology allows automatic identification of information contained in a tag by using radio waves. An RFID tag contains an antenna and a microchip to transmit and receive.

It appears as an alternative to barcodes that are facing the growth of the trade and new trade modes based on it. Indeed, if barcodes have proved, over a long period, their efficiency in data coding, they currently face some limitations such as the use of an optical reader (scanner) which has to be located at a relatively short distance from the identified object, or in a small data storage system.

The RFID technology is characterized by the deployment of three essential components: a microchip, an antenna and a reader. The tag is placed on the object or the person to be identified. It contains information that is decrypted by the server by using an antenna for transmitting signals between the reader and the chip. The radio frequencies used by the RFID technology are in the 50 kHz to 2.5 GHz range.

Therefore it is necessary to establish a comparison between the barcodes and the RFIDs, to understand why the RFIDs can replace the barcodes, and how they still have some limitations. The first difference between the two systems is their reading mode: a barcode is read by an optical laser, while an RFID tag is scanned by a reader that identifies the data contained in this tag. The reading distance of the RFID tags can be higher. Indeed, it extends from a few centimeters to 200 meters. In addition, the RFID tags can store more information than the barcodes, and the collected data can be up to several kilobytes. It is also important to note that the RFID tags can be recycled because new information can be registered in it. One of the drawbacks of the deployment of the RFID technology is its cost, which varies and can slow down its implementation, or perturbations between the tags and their sensitivity to interference waves.

The RFID technology is still a topic of great interest to many: it not only makes it possible to solve the problems faced by barcodes, but is also of importance to key sectors of economy and trade, such as distribution and transport. The implementation of this technology could revolutionize the pharmaceutical industry and represent a significant advance in the field of health which would benefit everyone: in fact, who would not expect to benefit from quality care and not like to avoid being a victim of medical errors? Applied to pharmaceutical products, smart tags would guarantee the authenticity and thus avoid counterfeiting. With regard to blood donations, their use would significantly reduce the risk of possible confusions. Medical staff would be able to authenticate the source of a blood sample without error, and thus lead to a correct transfusion.

It is clear that the RFID tags are more and more inescapable and deserve our attention. This was the main reason for us to write this book, which provides a description of the famous "smart tags" from a scientific viewpoint. It is divided into five parts: part 1 looks at the operation of the RFID systems. It establishes the classification of RFIDs, studies the physical aspect of tags and antennae, as well as coding techniques of RFID information. Part 2 is devoted to the application of RFID. It traces its evolution from the barcodes to the RFID tags by making a comparison between the two systems, and shows in a concrete manner various application examples of the RFID technology. Part 3 describes the cryptographic protocols of RFID.

The data contained in the tags must be identified without jeopardizing the privacy of the persons who possess them. Part 4 focuses on the global standardization of RFID: EPC (Electronic Product Code). It is a global architecture initialized by the Internet of objects and the desire to establish a large quantum of data for all products, while ensuring the specificity and authenticity of each one of them. And finally, part 5 attempts to describe the architecture to implement "the Internet of things" as efficiently as possible and by adapting to the evolution of needs: middlewares.

Guy PUJOLLE
April 2011

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PART ONE

Physics of RFID

Chapter 1

Introduction

RFID (*Radio Frequency Identification*) systems use electromagnetic waves to transmit, at distance, energy and data to devices that perform a scheduled process of information contained in these exchanges. The origin of RFID technologies, dates back to the invention of RADAR, where, during the Second World War, fighter pilots cleverly maneuvered their planes to be remotely identified by friendly radar operators, who distinguished them from their foes (*Identify Friend or Foe*).

However, the RFID technology received a boost in the early 1970s. The very first RFID devices were simple resonant analog circuits. Then, advances in microelectronics allowed the integration of increasingly complex digital functions. The initial applications were designed to track and monitor dangerous materials in sensitive areas (usually military or nuclear). In the late 1970s, applications of these devices also included the civilian doman, typically the monitoring of animals, vehicles and automated production lines [DOB 07].

Usual tracking technologies such as barcodes, invented in 1970 by an IBM engineer, have shown their limitations for applications in an altered environment, such as animal tracking or in the engine assembly lines. Indeed, the barcode must pass through a scanning window to be scanned by a mobile reader without obstacles or of dirt traces which degrade or block the reading operation. This is why RFID technologies are being developed to replace barcodes in identification functions, so as to make it possible to read or write information at a distance using electromagnetic waves.

Chapter written by Simon ELRHARBI and Stefan BARBU.

RFID technologies and contactless smart cards consist of one or more electronic tags connected to one or more antennae or terminals that radiate an electromagnetic field through their antennae. These devices communicate by RF (Radio Frequency) or UHF (Ultra High Frequency) channels. Some RFID applications and contactless smart cards require embedded energy sources to facilitate the data exchange between the tags and the terminal readers. Other more common RFID technologies and contactless smart cards perform remote energy transmission to enable data exchange.

Depending on the frequencies used, the transmitted energy necessary for operations can be stored in a geometric volume, site of an electromagnetic induction effect (as in the case of low frequencies or radio frequencies), or propagated (as in the case of Ultra High Frequency).

The deployment of RFID technologies presupposes that a number of electrical electronic, mechanical and material parameters have been controlled [ELR 04].

Indeed, given the nature of energy and data transmissions between the devices of the RFID system, the geometric space in which the energy transmission and data exchanges are performed may reveal communication failures between tags and terminals. In particular, the phenomena of echo due to reflection and absorption signals (as in the case of UHF) must be controlled. The coupling intensity in the near field (as in case of LF or HF frequencies) can degrade the signal to noise ratio or, in other cases, lead to very high impedance mismatch at the power stage level and cause a malfunction of the baseband station [BAR 05]. The antenna orientation of RFID tag/terminal pairs in correlation with the energy and data propagation should be minimized and the writing and reading distance should be optimized by taking into account the complete front-end architecture (stages of power, reception and power control). These issues (operational zones and antenna configurations) mainly relate to physical and electrical properties.

Regarding electronic aspects, the anti-collision processing should allow us to establish data exchange between all the RFID tags in the operating zone of the terminal(s) under the conditions predefined by RFID system specifications and ISO standards. The processing time of transmission, which should be secured by cryptographic algorithms, should be optimized (in terms of bandwidth and data rates), so that the processing time is compatible with the high flux of expected transactions.

Finally, the interoperability between different RFID systems, their robustness (in terms of electrical features) and their compatibility with ISO standards must be guaranteed. The mechanical parameters (connections between chips and antennas) and materials (from a point of view of electric behaviors) are all very important in this context.

By nature of their capture and data processing abilities, the RFID technology is well suited for automation of the complete supply chain, with better utilization flexibility

and operation under varying environmental constraints, even when the object is in movement and occupies various positions. RFID technologies follow the unprecedented development of international trade exchanges. These technologies make it possible to save money by avoiding logistical and human errors and by limiting fraud, irrespective of their origin [ROU 05].

Information system architectures that aggregate data from RFID systems are based on normative networks, which define international ISO standards, or the coalition of managers and assignees such as EPCglobal Inc. which implements EPC (Electronic Product Code) codes. These codes are allocated to objects for identification at a worldwide level, while providing an interconnection service to servers dedicated to identification and localization of objects by the Internet.

Today, due to the joint progress of micro-electronics, microcomputer and telecommunications, RFID systems are not only reserved for automatic identification, but have also spread to other areas such as secure access to buildings, to networks or the completion of secured transactions between remote electronic devices.

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Chapter 2

Characteristics of RFID Radio Signals

This chapter describes the main characteristics of electrical signals exchanged in RFID systems.

2.1. Description and operating principle of RFID systems

RFID systems typically consist of fixed elements (called base station, reader, coupling device, terminal, etc.), whose function is to identify and process, by using radio waves, the information contained in one or more deported elements such as transponders, tags, badges, electronic tokens, or contactless smart cards. The different designations of the fixed and deported elements may vary, depending on applications, contexts, and their hardware and software resources. The fixed elements are themselves connected to servers for data processing at middleware and application levels for analysis, archiving and traceability (Figure 2.1).

2.1.1. *Classification of RFID systems*

Because of the variety of devices, features, applications and uses, there are a multitude of possible classifications due to the avaliability of a variety of devices, features and applications. However, we can retain some of the recurrent criteria found in these systems, such as:

– operating frequencies;

– types of transponders;

– modes of energy and data transmission;

– features.

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