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Optimizing Processes with RFID and Auto ID

Fundamentals, Problems and Solutions, Example Applications

SIEMENS

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Preface

Herbert Wegmann

Herbert Wegmann is the manager of the Factory Sensors Division at Siemens AG, Industry Sector. Moreover, he is entrusted with the management of the group-wide AG RFID initiative.

RFID – the abbreviation for Radio Frequency Identification – has a real magic meaning. Contactless identification of all kinds of objects with electronically writeable data carriers in the absolutely low cost area with ranges of several meters provides an opportunity for several new applications: the ideas range from remote control systems for logistics centers ("internet of things") to an intelligent refrigerator that can automatically order goods.

However, contactless radio identification is not innovation as such and has been in use for industrial applications for a long time now. As a leading manufacturer of RFID systems, Siemens introduced the first industrial RFID system to the market 25 years ago. Moby M – the name of this first product – achieved a read distance between the transponder and antenna of, at most, 40 mm. However, the data carriers already had a storage capacity of 64 bytes. In the meantime, RFID is used successfully in several areas. However, despite the dynamism displayed by the development of RFID, it is not the only option available for identifying all kinds of objects. Optical codes such as barcodes – as printed on all consumer goods in supermarkets – are admittedly seen as outdated. However, the specific advantages of the optical processes that, for example, take effect with the 2D matrix code, can justifiably compete with RFID systems in some of their applications.

Technology fascinates people and is the key to economic progress. However, technology with no application focus only follows an end in itself. Therefore, this book takes a look at both aspects: technical basics and successful applications. In doing so, the issue here is how existing processes can be optimized by using RFID and optical codes, reducing costs, and increasing quality. Several chapters describe how automatic identification systems can be applied in a technically reliable and economically viable manner – from the factory floor to hospitals.

I am proud of the fact that the authors who have compiled such an exceptional scope in terms of content are all employees at our company or at least worked for Siemens previously for several years. Their contributions clearly emphasize Siemens' technological and solution expertise for RFID and Auto ID. Therefore, my sincere thanks go to all of the authors and the editorial team of Norbert Bartneck, Volker Klaas, and Holger Schoenherr. Special thanks also go to Leslie Miller, Michael LaGrega and Markus Weinlaender and Kerstin Springer for their project management and comprehensive editorial work.

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Part 4: How to proceed?

1 Introduction

Holger Schoenherr

The effort put forth to clearly and unambiguously describe objects and persons in our vicinity is as old as humankind. Names are a central element of all cultures and languages and are the root of our personal identity. Names create a basis for the targeted exchange of information: they form an access index for a specific quantity of information about an individual or item. Names can, therefore, be defined as information that is allocated to a person, an item, an organizational unit, or a term in turn enabling its/their identification and individualization.

The machine readability of the name and its symbolization play a central role in the automation of business processes. Therefore, innumerable items bear machine-readable individual descriptions such as plain text, barcodes, or electronically stored information: goods on a supermarket shelf, post consignments, machine parts, workpieces, transport containers, or ID card documents. Automatic identification includes the assignment, allocation, transmission, and processing of these descriptions. The results are then available for informational purposes, further analyses, statistics, control tasks, and for decision-making. It is essential that the processes and conditions from the real world are directly depicted in the world of information systems (IT). This results in enormous advantages for the entire value-added chain from production via logistics to the consumer.

Today, optical codes are the most common with an estimated share of 75 % of the total occurrence of identification systems. Symbols are captured by scanners that beam the barcode and measure the light reflected. The information included is decoded and processed by IT systems. In addition to the reflection principle, there are also scanners that function similarly to a digital camera. A world without optical codes is hardly conceivable any more. In the meantime, there are some 50 common specifications that are structured in a one-dimensional or multidimensional way, depending on their application, in which they require differing amounts of space and vary in their storage capacity. Billions of objects are marked in this manner; prominent examples include the barcodes on the articles in supermarkets. However, 2D and Data Matrix Codes have been established in industrial manufacturing processes. The reasons for this are the high storage density, robustness, and attachment options on a multitude of surfaces. A detailed explanation of the current state of the technology is covered in Chapter 3.

In addition to optical systems, Radio Frequency Identification (RFID) also plays a decisive role. The Scottish physicist James Clerk Maxwell (1831-1879) is recognized as the most important pioneer of this radio technology. When he postulated "Maxwell's equations", named after him, he did not suspect the speed at which radio technology would expand during the subsequent centuries (Fig. 1.1). In addition to other excellent scientists such as Heinrich Rudolf Hertz and Guglielmo Marchese Marconi, Maxwell was largely responsible for providing the basic contribution to the description of the entity, spread, and transmission of electromagnetic waves. The phenomenon of transmitting signals through the "airwaves" enabled humankind to push forward to new communication dimensions: the radio age had commenced. However, also in view of the huge steps forward, the idea of tiny, radio-emitting devices on items was dismissed as utopia up until well into the 20th century.

Since 2000, RFID has gained a high level of recognition, although this technology has already established and proven itself for several years in industry and company logistics. This has to do with the storing of information directly on physical objects using mobile data carriers. The data can then be read and written wirelessly.

$$\mathrm{rot}\, H = \dot{D} + j: \qquad \oint_k H \cdot \mathrm{d}s = \frac{\mathrm{d}}{\mathrm{d}t}\int_A D \cdot \mathrm{d}A + I$$

$$\mathrm{rot}\, E = -\dot{B}: \qquad \oint_k E \cdot \mathrm{d}s = \frac{\mathrm{d}}{\mathrm{d}t}\int_A B \cdot \mathrm{d}A$$

$$\mathrm{div}\, D = \varrho: \qquad \oint_A D \cdot \mathrm{d}A = Q$$

$$\mathrm{div}\, B = 0: \qquad \oint_A B \cdot \mathrm{d}A = 0$$

Fig. 1.1 With the equations named after him, James Clerk Maxwell also laid the foundations for RFID (Photo: Pixtal)

1.1 Historical Development

What use does wireless communication with items have? One response was born during the Second World War. In unclear air-to-air encounters, one's own aircraft and the enemy's aircraft were frequently confused, which resulted in fatal consequences. That is why scientists from the US Navy research laboratory (NRL) as well as British experts started working on a system to distinguish allies and enemies in 1937. When the radar signal from the ground station strikes a device that is located onboard it responds with a code and transmits it to the interrogator ground station's radar frequency. The analysis of this information enabled the identification of all aircraft, in turn distinguishing between allies and enemies. Because the device transmits and responds, it was called the transponder, which is a description that has been maintained up to present times for the RFID data carriers. The further-developed forms of the transponder are now onboard all aircraft today and are essential for air traffic control as well as the effective management of flight progress (Fig. 1.2).

With this view, we have approached the most important aspects of RFID. Communication is wireless, in which there is no need for a visual connection.

No manual operation is required, in which the information that was previously stored is transmitted. Processes that to date were complex and not transparent have become transparent as a result. On the other hand, this provides the opportunity for a targeted exertion of influence.

Admittedly, the first transponders were as large as a suitcase, correspondingly heavy and were high energy consumers. Developments in the field of transmission technology, integrated circuits, and semiconductor technology soon made them significantly smaller and at the same time this led to higher performance transponders. At the

Fig. 1.2 The basic principle of RFID is still used for the identification of aircraft today. This simple transponder can transmit a four-digit code as well as the aircraft's altitude (Photo: Garmin Ltd.)

Fig. 1.3 We can no longer envisage today's commerce without barcodes – as shown here at a modern scanner checkout counter. (Photo: Wincor Nixdorf)

outset of the 1970s, article surveillance systems were introduced in sales rooms. To begin with, single-bit transponders were used, in which, technically speaking, they were simple LC elements that only displayed their presence in the read field. If a customer "forgot" to pay for an article, a high-pitched beep reminds them when passing through the scanner gate at the exit. Such devices are installed in virtually all department stores nowadays.

At about the same time, barcodes were implemented as an optical identification system for commerce. In 1974, Wrigley's chewing gum was the first product marked with a barcode that was machine-scanned in supermarkets. The triumphal march of the barcode and standards connected with it such as the European Article Number (EAN) were inexorable (Fig. 1.3). Therefore, the barcode only needed a little less time for wide scale market penetration than RFID, because the first barcode patent was already applied in the USA in 1949.

At the beginning of the 1980s, applications for marking livestock arrived and consequently the use of RFID for individualization spread. As opposed to article surveillance systems, a comparatively large memory is required for these transponders, enabling the storage of data such as an unambiguous number or the animal's date of birth. The USA and Norway developed RFID-based toll systems. RFID was also introduced in production work for manufacturing controlling. The first industrial RFID systems, such as Moby M from Siemens, were still designed as active components from a device-related view-

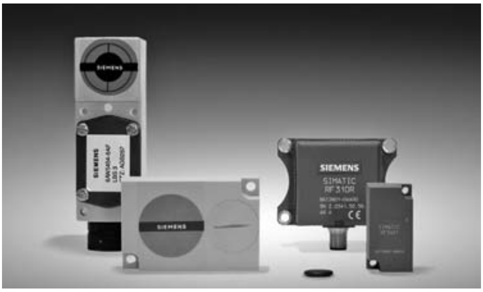

Fig. 1.4 Siemens has provided RFID to industry for 25 years: on the left-hand side “Moby M” from 1983, and on the right-hand side the current Simatic RF300 system.

point (Fig. 1.4), for which a battery provided the energy that was required to operate the internal circuit elements of the transponders. Despite this, the range was only a few centimeters.

With the foundation of the AutoID Lab at the Massachusetts Institute of Technology (MIT), a new chapter in the history of RFID technology was opened. RFID literally became the synonym for automatic identification and for the automatic transparency of logistical processes. The terms “internet of things” and “RFID” have been inseparably connected since then. The target: a global solution for the comprehensive tracking of articles based on a biunique number. All articles according to this approach are equipped, by the manufacturer, with an RFID transponder, in turn enabling automatic recording all along the supply chain. The data gained reflects the status of the full supply chain at all times and thereby enabling its comprehensive optimization. This concept is based on very low cost and at the same time high-performance disposable transponders, the so-called Smart labels with sufficient memory and a range of several meters.

Furthermore, a global data standard – the Electronic Product Code (EPC) – and a global IT system for the provision of individual product information are defined.

1.2 Proven in several applications

Auto ID and RFID are effective as *backbone* technologies for the future global economy. There are various reasons that make wide scale introduction a necessity. Therefore, the worldwide export of articles grew four times faster than production in 2005, when measured related to the gross national income (GNI). Added value cycles spread out worldwide, in turn adapting to the changing market requirements highly dynamically. Competition among companies is global; static supplier relationships give way to dynamic sourcing, which is controlled via the Internet. Therefore, for example, in the automotive industry the manufacturers' own real net output ratio will drop from 35% in 2006 to 25% in 2015. However, the structure of added value changes. The deliveries to date predominantly consisted of similar type components. However the trend now is towards knowledge-based supplies. In addition to automotive engineering, the aircraft industry also exemplifies this. Here, complete segments or assemblies are delivered prefabricated. Agility, fast reaction times, and the ability to react flexibly to the end manufacturer's changes form the basic requirements of all suppliers. Finally, the customers' requirements regarding the products' increase – similar articles that are "mass produced" become less and less accepted, especially for high-price technological articles. This development towards *"mass customization"* requires vast consistency of the processes – from design to production. The logistics chain also plays a decisive role. Deliveries must arrive at the customer's location as was ordered and be coordinated with precise timing in the correct order – only in this way is it possible to realize the *just in time* and *just in sequence* concepts. The systems for automatic identification are also essential here.

Wireless automatic identification is already "state-of-the-art" for production technology in many cases. Automatic control of the production processes based on individual object data is the focus for these applications. For example, spray robots in automotive engineering are controlled dependent on the car body shape (e.g. cut-out for a sunroof) (Fig. 1.5). In brief: the products bear all the information for their processing and assembly. This enables the implementation of fully new, decentral manufacturing controlling concepts. The automatic recommencement of manufacturing using the status information that is directly stored on the workpiece is a further advantage. The data carriers that are used are robust and move in closed loops with the workpieces or workpiece carriers. At the end of a run, the data are saved, the transponder is deleted, and then sent into the next circulation. If the number of runs increases, the cost share of a transponder per run is naturally reduced. Therefore, such applications often pay off within less than two years.

Foodstuffs, drugs, and technical components are three completely different application areas. For example, the full integrity of the pro-

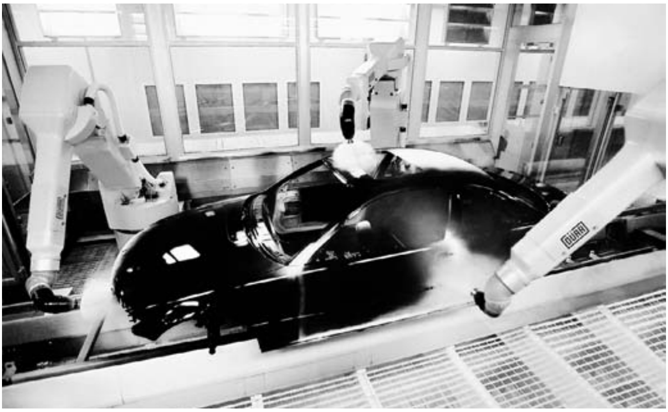

Fig. 1.5 Where vehicles are painted in the automobile industry, RFID has shown to be "state-of-the-art" for several years now. (Photo: Duerr AG)

duct is essential within the pharmaceuticals supply chain. It must be guaranteed that the correct and, above all, original drug is provided to the patient. The term "E-Pedigree" describes the "electronic family tree" of such products. Moreover, gapless proof of the origin and stations of the supply chain will become compulsory in the future. This is only possible if automatic identification technology is used. The 2D code is favored at item level and RFID at the box and pallet levels. However, current experiments in the pharmaceuticals industry are also directed at testing the performance capability of RFID at item level. One reason for this is that RFID could also be used as an electronic authentication certificate.

Furthermore, the administration of assets is one of the most promising areas for the application of RFID. Here, above all, it is a question of the stock optimization of the transporter wagons, circulatory containers, and tools required. On the one hand, sufficient quantities of these assets must be available in order to be able to produce and supply. On the other hand, assets are fixed capital with no direct yield, in turn making it desirable to strive for the lowest possible stock. Thanks to RFID, the life cycle can be reconstructed without a gap and for assets that leave the area of accessibility of a company with a clear statement that can be made as to where an asset is located. In addition, thanks to the RFID transponders on various objects, it is also possible to add further processes to RFID-supported asset management, and thereby further increasing the profitability of this respective solution.

Moreover, numerous specialized RFID and Auto ID applications can be found in individual industries. The identification of patients in the healthcare sector, management of supply logistics for automobile manufacturers, or controlling luggage transport platforms at airports are just some selected examples.

1.3 Innovation as a driver

The history of automatic identification is marked by constant innovation. All new developments enable new applications. However, at the same time restrictions such as the read rate remain. Things that we could not possibly dream of 10 years ago are a reality today. Additionally, today's problems are resolved tomorrow, by using elegant solutions. Technologists and scientists work on varied topics of which three should be emphasized here.

One of the most important objections to the mass use of RFID transponders today is the data carrier costs. One possible approach to the solution to this is the use of printed electronic circuits. The materials that are used are polymers with semiconductor properties. The advantage: the integrated circuit of an RFID data carrier can be produced in just one single process step. That saves on costs and smoothes the way for transponders in the 1 cent range.

The enrichment of RFID with additional functions results in a new dimension of applications. Today, sensors for recording ambient parameters, such as temperature, pressure, and acceleration are already combined with RFID transponders. These are the first three steps to autonomous, intelligent systems that interact with their environment. We envisage transponders in the future that make decisions independently that are based on ambient data.

Within the course of decentralization and mobilization of information, fully new aspects of data security become increasingly important. If, for example, RFID transponders are used as an authentication proof for drugs, it must be technically impossible to copy the microchip included. The use of asymmetrical cryptography in passive low-cost transponders is beneficial here.

However, the inventiveness of engineers and scientists is not merely restricted to the radio protocols or the chip design. On the contrary, the promising linkage of a long range and acceptable storage capacity along with the lowest transponder prices also make fully new architecture in production and logistics systems conceivable. The key word "internet of things" makes the exact direction clear: towards distributed, autonomous systems that do without a central control component, which is similar to the Internet. The mobility of the data achieved by Auto ID and RFID forms the basis of a new development step in the design of those complex systems that are increasingly affecting our lives.

Part 1

Technical Fundamentals

2 RFID technology

Dieter Horst

The abbreviation RFID has also been current outside professional circles for a few years. The massive spread of these systems in trade and logistics and not least the hype triggered by UHF-RFID helped the term on its way to the IT press and even to daily newspapers. But what does this term actually mean?

2.1 What is an RFID system?

RFID stands for Radio Frequency Identification – unfortunately, this is not very meaningful. Therefore, I propose the following definition:

> An RFID system comprises of at least one reading device and one mobile data storage unit that can be read contactlessly by a reading device using a high frequency transfer procedure.

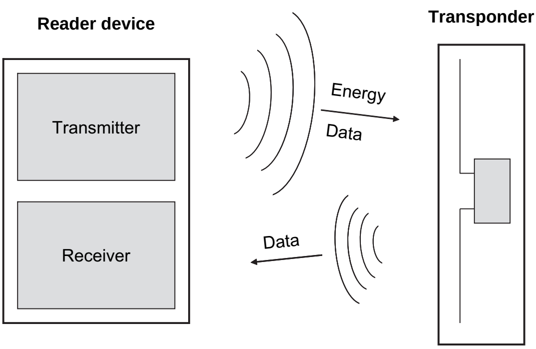

Fig. 2.1 Illustration of an RFID system