

Use of RFID Technology for Identification, Traceability Monitoring and the Checking of Product Authenticity

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Abstract—This paper is an overview of the structure of Radio Frequency Identification (RFID) systems and radio frequency bands used by RFID technology. It also presents a solution based on the application of RFID for brand authentication, traceability and tracking, by implementing a production management system and extending its use to traders.

Keywords—Radio Frequency Identification, Tag, Tag reader, Traceability.

I. INTRODUCTION

RFID is a prospective automatic identification method, being considered by many as one of the most pervasive computing technologies in history [1].

RFID is based on storing and remotely retrieving data using devices called RFID tags or RFID transponders [2]. An automatic identification technology such as an Auto-ID system based on RFID technology is an important asset for inventory systems for two reasons. First of all, the visibility provided by this technology allows an accurate knowledge of inventory level by eliminating the discrepancy between inventory record and physical inventory. Secondly, RFID technology can prevent or reduce sources of errors. Benefits of using RFID technology include the reduction of labor costs, the simplification of business processes and the reduction of inventory inaccuracies. An RFID technology also provides equipment traceability knowledge in an organization.

RFID is a technology with important business value and huge potential. RFID promises to replace the old barcode and contributes to the real time visibility of the goods, regardless of the location of the supply chain. We find RFID applications in various fields, but its main use is in tracking objects (assets) [3].

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In its simplest form, RFID is a concept similar to barcode technology, but without requiring a direct visibility of the monitored entities. Just like bar code systems require a proper optical reader and special tags applied on products, RFID needs a reader equipment and special tags or cards attached to the products in order for the products to be tracked.

At the European level, the European Committee for Standardization promotes the development of international standards for identification technology and automatic data collection.

The European Telecommunications Standards Institute has developed specific standards for RFID which operate at Ultra High Frequencies, as well as generic standards for the short range devices, applicable to equipment operating in areas of low (LF) and high (HF) frequency and with microwaves which can be used for RFID [4].

The Commission appeals to the European standardization bodies so that, in cooperation with forums and consortia of the specialized industry, to ensure that European and international standards are in accordance with the European requirements, especially regarding issues such as privacy, security, property rights (intellectual authority), to identify standardization gaps, and to provide a proper framework for the development of future RFID standards.

The lack of standardization and harmonization of frequency allocation is an obstacle to the development of this industry. ANSI and ISO have worked together to develop RFID standards and have adopted such standards for applications such as animal tracking (ISO 11784 and 11785) and the tracking of goods in a supply chain (ISO 18000 - 3 and ISO 18000-6).

II. STRUCTURE OF AN RFID SYSTEM

Generally, the RFID systems have three components - a reader, a tag (transponder frequency) and a data processing system, based either on a PC or on different microcontroller [5]. RFID systems use transmission through radio frequency in order to identify, classify and locate "articles" which are primarily objects, but also people or animals. The reader contains electronic components which send and receive signals to and from the proximity tag, a microprocessor that checks and decodes the data received and a memory that records data results, which are then transmitted forward if

necessary (Fig.1) [6]. In order for the reception and transmission of data from the tag to be possible, the reader is provided with an antenna. The antenna can be integrated into the reader's case or can be separated, located far from the rest of the electronics. As for most radio frequency applications, the antenna diameter must be relatively large in order to obtain good performances.

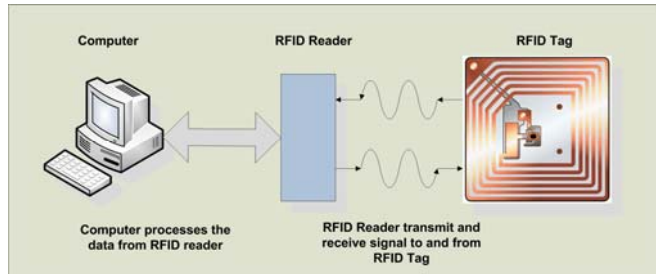


Fig. 1 Transmitting data to and from RFID tag

An RFID tag contains circuits that control the communication with the reader, generally integrated into a monolithic circuit. It contains at least two sections [7]:

- One section that provides communication with the reader;
- A memory section, with the role of storing identification codes or other data, which is activated along with the communication.

When an object equipped with a tag passes through the action area, the tag reader detects the generated signal and starts communicating the information stored in memory. In the case of passive systems, the signal generated by the reader provides both temporal information and enough power to ensure operation. The tact signal (time information) synchronizes communication between tag and reader, simplifying their constructive design [8], [9].

III. FREQUENCY RANGES USED BY THE RFID TECHNOLOGY

Due to the different radio spectrum in the range of which it operates, the RFID equipments (and implicitly their applications) are classified into several categories [10]. Choosing the optimal frequency band for RFID applications is primarily dictated by the environmental conditions in which the system must operate and by application requirements.

The operating bands for Europe and Africa are:

- *Low frequency (LF - Low Frequency)*, $F = 125/134$ kHz - inductively coupled devices, for which most countries do not require authorization systems operating in this band. The characteristics of this range are:
 - Typical applications: animal identification, access control, container management;
 - Reading distance: 0,1 to 1 m;
 - Excellent performance near metal or liquids.
- *High Frequency (HF - High Frequency)*, $F = 13,56$ MHz - electronic surveillance elements. The

characteristics of this range are:

- Typical applications: inventory-archive documents, luggage screening, transportation;
- Reading distance: 1 to 3 m;
- This frequency band covers most of the possible applications.
- *Very High Frequency (Ultra High Frequency - UHF / MW)*, $F = 850$ MHz – 2,46 GHz. Includes two ranges:
 - for the frequencies between 430 and 460 MHz – industrial, scientific and medical applications;
 - for the hyper frequencies between 2,35 and 2,45 GHz - distributed spectrum applications.

The characteristics of this range are:

- Typical applications: transportation, parking, container management;
- Reading distance: 1 to 12 m;
- Enables the identification of the vehicles moving at speeds exceeding 100 km/h.

IV. USING RFID TECHNOLOGY IN THE IDENTIFICATION, TRACKING AND TRACEABILITY AUTHENTICATION OF PRODUCTS

For the purpose of ensuring the authenticity of products and establishing the route followed by a product, one can implement a production management system using RFID technology and expand its use to trading point. Implemented workflow management systems on manufacturing and transport currently exist, but the chain is not complete, since such systems and a database containing all the information are absent in outlets.

This paper presents a reliable and low cost solution based on the application of RFID technology, both for product brand authentication, as well as for the monitoring of their traceability whilst ensuring information support for distribution control (Fig. 2).

Furthermore, in order to eliminate any doubt related to product transport or storage under improper conditions, the project will conduct research to find solutions for monitoring ambient parameters by storing the information obtained throughout the duration of transport or during storage in the memory of an active transponder (coupled with special sensors). Corresponding product traceability information will be read and recorded at each distribution point / center or outlet. Thus, the final consumer will get a product with a transponder / tag attached, in which data on all essential product information and the route it has followed is stored, including the one related to the final store where the product is located. Customers can check this data using a portable or fixed embedded reader, for example a PDA or mobile phone. If the client wishes, after purchasing the product, he will be registered as the product's owner.

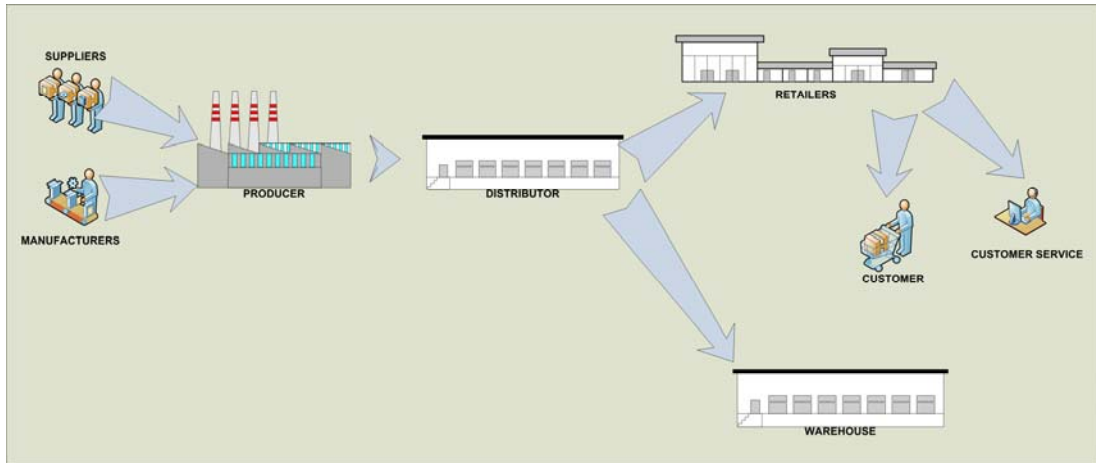


Fig. 2 The general architecture of a supply chain

Therefore, a product will be authenticated by three methods accessible to any citizen:

- *product tag* authenticity (hologram, other traditional authentication elements);
- *electronic chip* authenticity of the RFID tag accompanying the product and containing information on traceability and originality of the product;
- *Web site* authenticity based on a unique product ID code for comparing information from the database with

that of the electronic chip's official manufacturer.

This will ensure maximum system safety, the sharp decrease of the possibilities of product piracy, increased buyer safety regarding purchased products and a modern and efficient management and tracking system for their products.

The bidirectional information flow of the producers, distributors and retailers' paths is shown in Fig. 3.

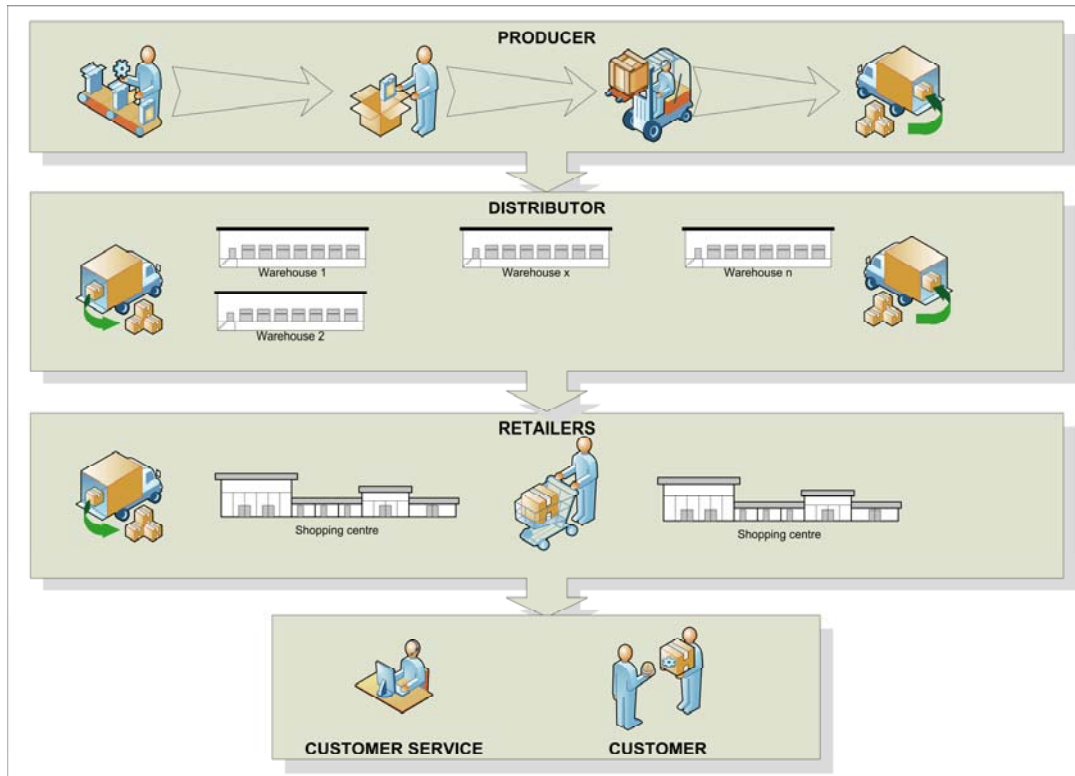


Fig. 3 Information flow of the producers

The information flow of the producers includes the following steps taken to ensure traceability:

- Manufacturer product labeling with RFID tag and the inscription of the original information in the RFID transponder's memory. Products are packed in packages labeled with RFID tags and which contain the initial information about the package. The package code is associated with the product codes from the package. The updating of the manufacturer's databases will continue based on the package code until the retail sale of products. The product is stored together with this information into the transponder's memory in the producer's product warehouse and information is transmitted to the producer's server that contains the end product database
- When supplying products from the manufacturer's end product warehouse, the date and the warehouse's code will be entered into the memory of the package tag. The information is transmitted to the manufacturer's server via the Internet.
- On entering products into the distributor's warehouse, the information from the package's tag will be read and sent to the producer's server. The tags on the package and products will contain information concerning the reception in the distributor's warehouse. On leaving the distributor's warehouse, the information on the package tag will be read and sent to the manufacturer's server. The information regarding the release from the distributor's warehouse will be entered into the package's tag and into the products' tags for each product within the package.
- If there are other distributors in the distribution chain, the previous step will be repeated. It is anticipated that there will normally be 3 distributors per supply chain (international, national, regional).
- On entering products into the retailer's warehouse, the information on the package tag will be read and sent to the producer's server. The information concerning the reception in the retailer's warehouse will be entered into the package's tag and into the products' tags for each product within the package. Package labels will be destroyed and the manufacturer's server will be informed.
- In order for the product to be sold, authentication will be performed by using an application that can run either on a PC or a PDA connected to an RFID reader.
- If the product is sold, the retailer has the obligation to register this in the manufacturer's server. This will register the fact that the product with a certain code and traceability information has been sold. An attempt to sell a potential counterfeit product having a cloned tag will be detected when the information concerning the product is checked on the producer's server. A message stating that the product has already been sold will be returned by the server in this case.

Furthermore, the server will inform the producer that there was an attempt to authenticate a counterfeit product.

- An additional RFID tag recording the temperature in a given period of time and with a certain frequency (both programmable through applications running on the manufacturer's and distributor's warehouses) can be attached in certain segments of the supply chain. The temperature recording can also be done when storing products. Information stored in an RFID tag with a sensor will be downloaded using a RFID reader and further sent to the manufacturer's server. When the product's tag will be detached from a monitored product, the manufacturer server will be informed of this. The tag can be reused.

Electronic tags can optionally be attached to the product after the sale (eventually for service). Tags other than the tags that recorded temperature (and which are attached to packages / products) cannot be reused.

V. ADVANTAGES OF USING RFID IN SUPPLY CHAINS

Among the advantages of using RFID in supply chains can be mentioned.

- RFID provides the automated management of the supply chain, allowing companies to realize significant savings;
- RFID brings an important contribution to the maintenance of record accuracy for product reception and shipment;
- RFID prevents product theft by registering the product at multiple points and creating a record of the route followed by each product;
- RFID has the capability of identifying the product's location, useful especially in case of the product's loss, which allows the manufacturer or distributor to take a form of corrective action.

As a result, RFID technology has a major contribution to the quick location of a product, as well as eliminating opportunities for its falsification.

Supply chain management based on RFID technology faces a number of challenges, especially regarding security operations. It is obvious that the assembly of all of a product's electronic attributes plays a vital role in obtaining benefits for supply chain management systems, but the security of this assembly, the elimination of unauthorized access, the modification and the prevention of illegal product manufacture are still challenges for RFID. Currently, there is a major interest in the cloning of RFID tags, which would allow the introduction of counterfeit products in supply chains.

VI. CONCLUSION

The large use of RFID can bring benefits such as:

- Increasing efficiency and productivity by: the fully automatic identification, possibly by counting, tracking, sorting and routing; efficient data collection

and identification; reducing errors and losses; achieving better inventory; efficient monitoring of objects and people's mobility; access control;

- Increasing profitability by: reducing operational costs; reducing costs related to human resources; reducing process duration; providing efficient quality control; assuring lower maintenance costs compared to other identification systems;
- Increasing customer satisfaction by: providing more accurate information; reducing subjectivity and supporting responsibility; providing higher quality products and services; offering competitive prices; rapidly adapting to market dynamics.

RFID identification technology accelerates data collection and eliminates human intervention.

RFID technology is the cheapest solution if it is evaluated on the long-term.

From a practical perspective, RFID tags cannot be replicated. The RFID technology offers fast reading tag speeds of tens of milliseconds. The labels used are resistant and it is possible to operate with them in an environment whose temperature varies between -40°C and 100°C.

REFERENCES

- [1] *RFID Journal Frequently Asked Questions*. <http://www.rfidjournal.com>.
- [2] *Examples of AIDC*, <http://www.rfidgazette.org>, 2005.
- [3] *What is Radio Frequency Identification (RFID)?* <http://www.peacocks.com.au/about-rfid.htm>.

- [4] *ISO RFID Standards: A Complete List*. http://rfidwizards.com/index.php?option=com_content&view=article&id=242.
- [5] R. Lixândriou, "A Model of Traceability for Equipments Using RFID Technologies within an Integrated System," in *Revista Informatica Economică*, no.2(38)/2006, pp. 124–128.
- [6] G. Pescaru, R. Dragomir, S. Puşcoci, "Activities optimization using RFID technologies," in *AGIR Bulletin – Telecommunications*, no.2/2008, pp. 66–78.
- [7] *RFID – Radio Frequency Identification*. <http://ro.wikipedia.org/wiki/RFID>.
- [8] H. Bhatt, B. Glover, *RFID Essentials*, O'Reilly, 2006.
- [9] S. Lahiri, *RFID Sourcebook*, Prentice Hall PTR, 2005.
- [10] *Frequency for RFID Systems*. <http://www.rfid-handbook.de/rfid/frequencies.html>.



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