Research Article

Remote Management and Tracking System for Commercial Refrigerators Using UHF RFID Technology

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Abstract

In this study, RFID based solution was developed for the commercial medical type refrigerators to identify products, expiration dates, and monitorize the entire life of products from the manufacturer to the end user. The medical products such as vaccines, drugs, blood and plasma products will be tracked, and product losses will be minimized with this solution. The results showed that UHF RFID system successfully identified the products in the commercial type refrigerator. Thanks to the RFID technology to be used in the designed project, the RFID tags on the product were automatically read for each product entering the refrigerator, and the products were monitored and managed via a web-based control panel.

Keywords: *RFID systems, medical type refrigerators, commercial refrigerators, tracking system*

1. Introduction

Nowadays, the competitive environment of companies and sectors changes very fast. Companies need to renew their services, products and communication technics, in order to use the time and sources efficiently. Therefore, automatic object identification, data gathering, and data management technologies have gained importance in recent years. Internet of Things (IoT) has rapid development and, requirements for sensing layer of the Internet of Things have been investigated in detailed. RFID is one of the perception layer technologies in IoT systems and technologies which provides data gathering, monitoring and tracking [1; 2]. The important features of the RFID technology are, data read capacity,

variable read distance, tag durability, lifetime, label diversity, information storage capacity, data/information flexibility, contactless, high-speed, low-cost, long-life, pollution-against, hash environment-adaptive, data security, and service network [1; 3].

RFID can be applied to different areas such as supply chain management, traffic monitoring, health and biomedical applications in industry. In this paper, a RFID system that could be implemented in a commercial refrigerator was developed. The main problems are inadequate stock management, expiry date (EXP) and maintaining the cold chain while transporting medical supplies and samples such as antibiotics, vaccines, blood samples etc. in the commercial type refrigerators used in medical sector. These problems were reported by the partners and our customers from the industry and commercial type refrigerator manufacturers. Therefore, based on these requirements and meeting the partner's needs and expectations, an RFID system was designed, examined, and implemented on the medical type of commercial refrigerators. With the help of the RFID tag, which is implanted on the medical product, the expiry date, name, description of the product, the location of the refrigerant, and the entered in and exited time from the refrigerators can be monitored and managed. High Frequency RFID technology was used for the RFID tagged products. High Frequency RFID Antenna simulation and calibration were performed in order to increase the antenna efficiency.

RFID based commercial refrigerators are cloud-based platform software solutions which enable track the expiry date, temperature and reducing shrinkage. It allows 24/7 temperature monitoring. It will be possible to know who took thewhich product and when. As a result, the developed system can be applied in a wide range of sectors as well as the medical sector since the bottles could be used in the whole life cycle of an FMCG product (production, logistics, marketing services, recycling and others).

2. Materials and Methods

In this study, RFID antenna (Caen), tags (ST Microelectronics), RFID reader (ST Microelectronics), Raspberry pi controller and two cabinets which one of them is plastic and metal were used to set-up the system (Figure 1). The RFID tags are sensitive and there are some problems when the tags are mounted on different surfaces such as metal or containers of liquids. Therefore, plastic vials were used to avoid this problem. Since the position of the RFID tags were not fixed and the angles varied, a circular type of ultra-high frequency (UHF) antenna was used. UHF RFID antenna is very sensitive. Therefore, the gain problem could be occurred in UHF RFID systems. UHF systems can cause interference due to reflection or re-radiation of power signals. Therefore, position planning and calibration of antenna or reader tuning should be performed. In this study, antenna calibration was performed by ST Evaluation tool. Also, the metal frame was another problem. The antenna being affected and spoiled the signal. To prevent this problem, the materials used are especially plastic. Plastic shelves were used instead of metal shelves in the cabinet. In the calibration settings (ST Evaluation tool) the lowest levels were used (Figure 2). So, it was required to use two RFID antennas in the cabinet. By using two antennas, it was ensured not to be affected by external factors and only the signal was used for the labels in the cabinet.

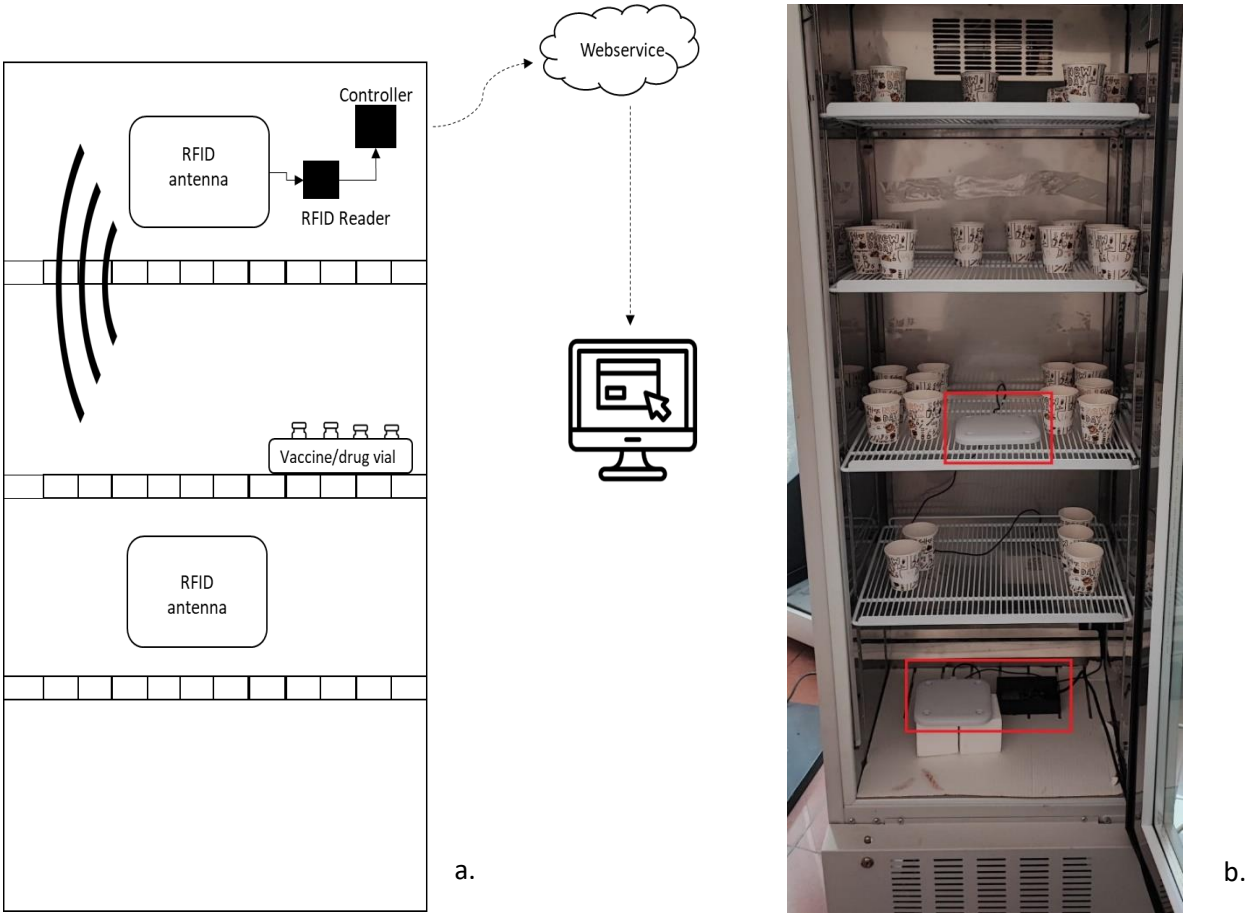


Figure 1: Experimental set-up of RFID system in the medical commercial type refrigerator a. block diagram of the set -up, b. real set-up

Bandwidth was in the range of 865-867MHz. An IP65 protective layer was applied so that the antenna was not affected by environmental factors such as humidity and temperature.

RFID transfers and receives signals using Antenna which receives data from the tags and transmits data to the RFID reader. The reader then converts the radio waves to usable type of information. The data collected from the RFID tags is transferred through a controller to a computer system, where the information can be stored in a database. Firmware (FW) was developed for RFID and controller cards. The related code was compiled by Linux make and debugged.

A program that will send the tag information to the controller via UART was developed by C++ in Visual Studio. On the controller side, the Java-based program developed with Eclipse will transmit the tag numbers to the web service over HTTP with the information it receives from the refrigerator main board. After the firmware work, a program was developed that reports the information received from the RFID reader and

refrigerator main board via UART to the web service via HTTP by adding date, time and location information of the products.

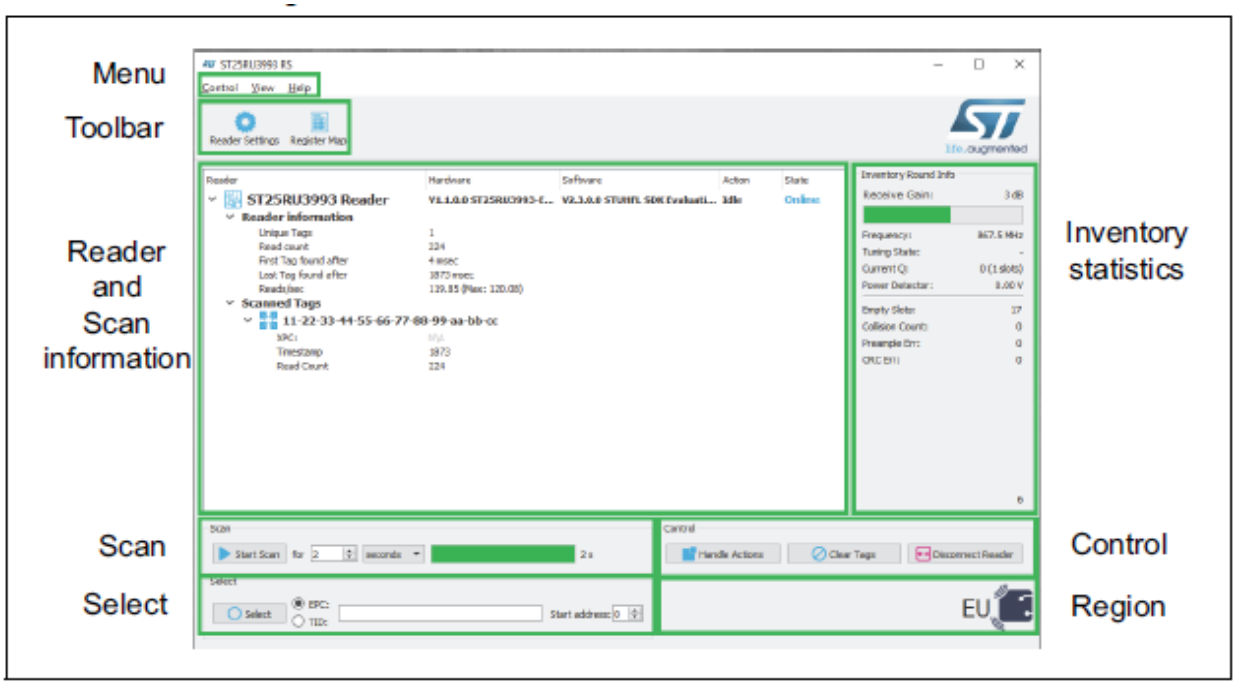
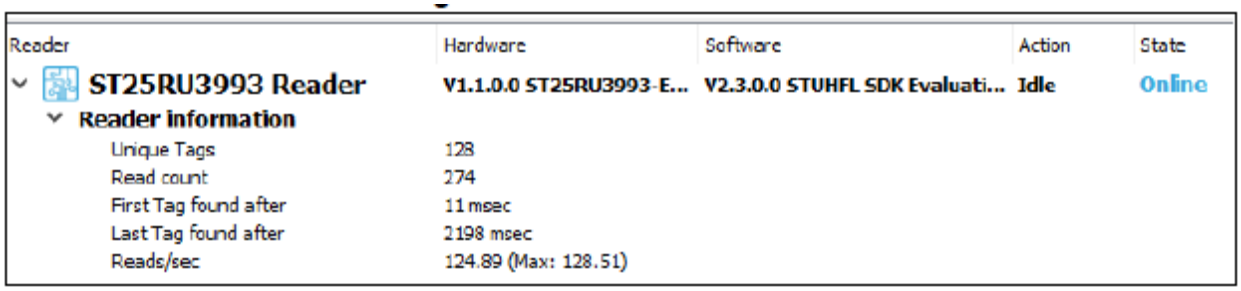


Figure 2. RFID calibration setting

3. Results and Discussion

In this study, it was presented an automatic identification system to determine and track the products/contents in the commercial type refrigerators. Radio waves were used to automatic identification of objects in the test environment. The test results were presented in Figure 3 and Table 2. Object information and credentials were successfully identified and visualized as a numeric serial number. The success rate was found as 100% in the tested system. As a result, the RFID based system could be a potential in the commercial type refrigerators used in medical sector.


Reader
Hardware
Software
Action
State
ST25RU3993 Reader
V1.1.0.0 ST25RU3993-E...
V2.3.0.0 STUHFL SDK Evaluati...
Idle
Online
Reader information
Unique Tags
128
Read count
274
First Tag found after
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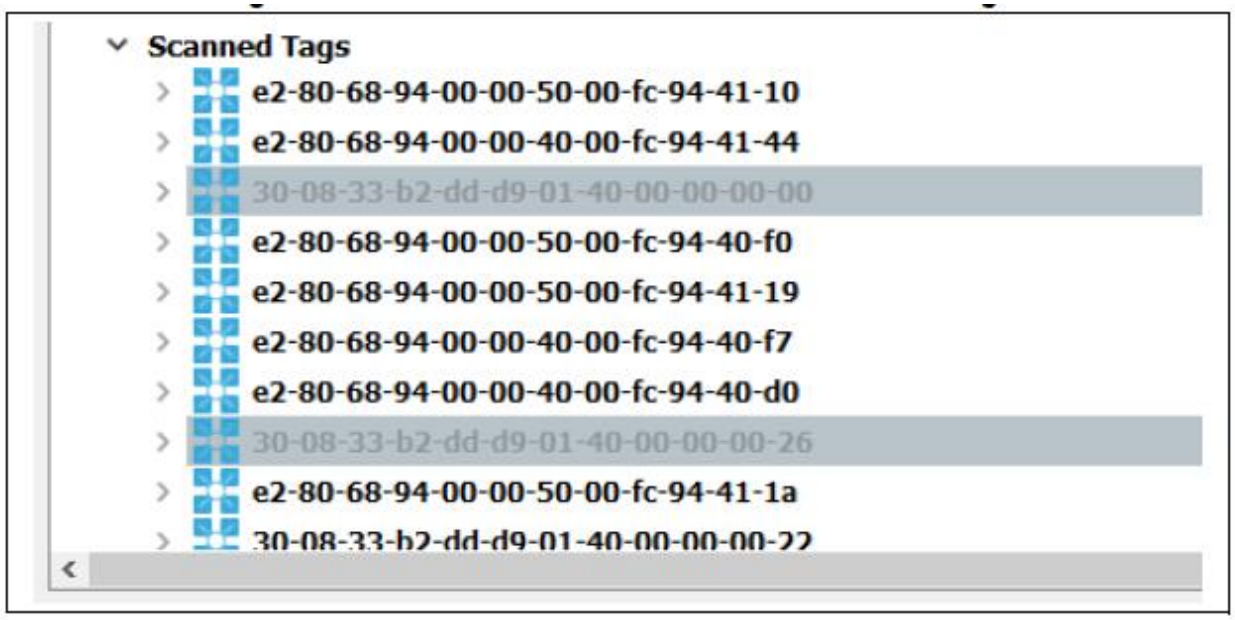
Last Tag found after
2198 msec
Reads/sec
124.89 (Max: 128.51)


Scanned Tags
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e2-80-68-94-00-00-40-00-fc-94-41-44
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e2-80-68-94-00-00-50-00-fc-94-40-f0
e2-80-68-94-00-00-50-00-fc-94-41-19
e2-80-68-94-00-00-40-00-fc-94-40-f7
e2-80-68-94-00-00-40-00-fc-94-40-d0
30-08-33-b2-dd-d9-01-40-00-00-00-26
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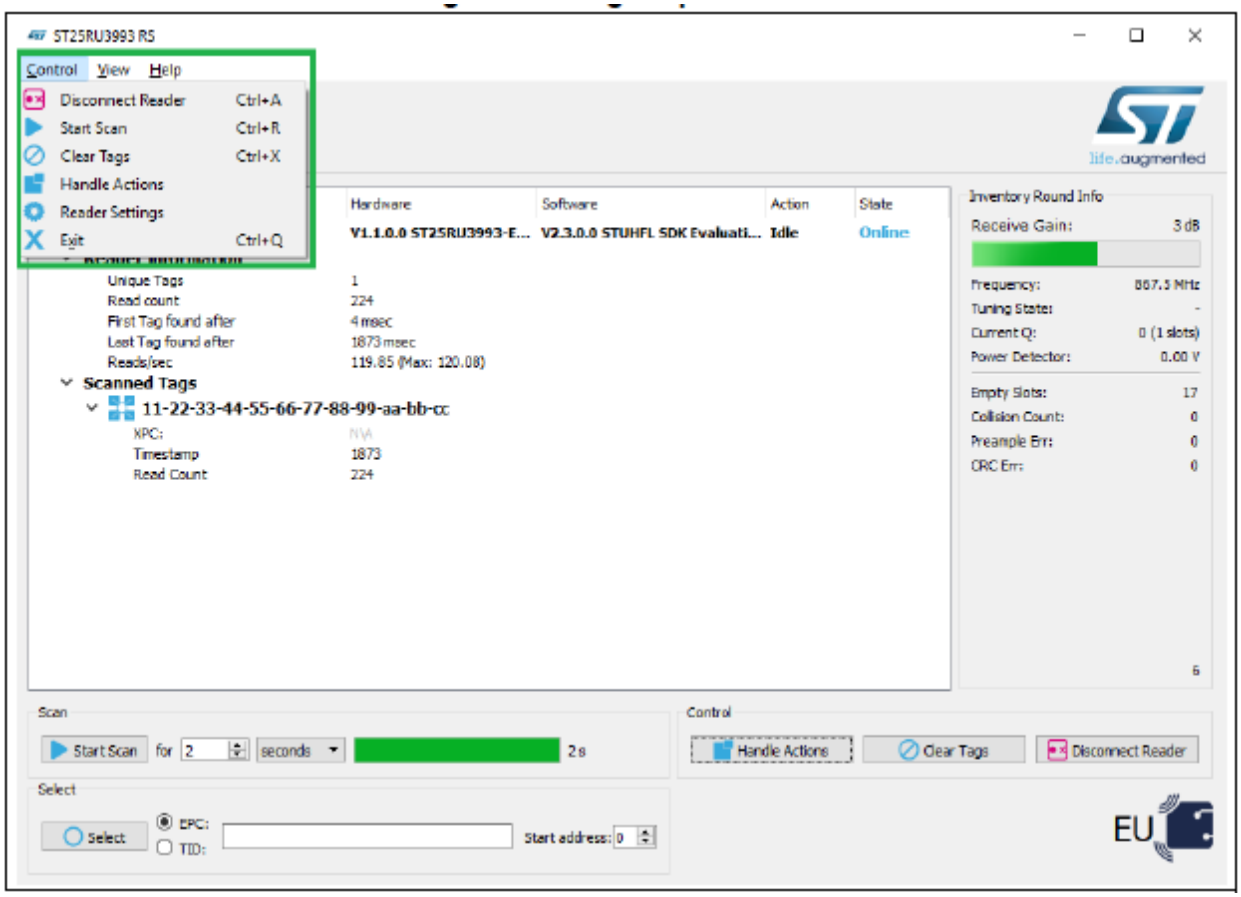

Figure 3. Test results

Hardware tests were performed for RFID Reader, RFID tags, RFID Antenna and Controller according to the set up shown in Table 2.

Table 1. Test results for the RFID system

Test Number	RFID Tag Tested	Read Count	Time
01	224	224	1873 ms
02	224	224	1978 ms
03	224	224	2416 ms
04	224	224	3252 ms
05	224	224	1237 ms
06	224	224	1996 ms
07	224	224	2087 ms

4. Acknowledge

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