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IDENTIFICATION AND MONITORING OF THE CONTAINER AT THE POSTAL OPERATOR

ABSTRACT

Article provides research in field of automatic identification of container through radio-frequency identification technology (RFID) in terms of supply chain of particular postal-logistics operators. In this article we would like to share knowledge of testing and the results that we found during the test in laboratory and also real conditions in conjunction with selected postal operator. The ambition of this work is selection of appropriate identifier type and its placement on a container. A special section is dedicated to description of the technical equipment used during measurements as well as their results from MySQL database. At the end of article is described pilot, where the selected area at the selected postal operator and its processing centers were equipped with RFID readers that were connect over a network to the central database server. At intervals of a few days we monitored movement of objects equipped with RFID tag in real time. The captured data form this testing were used as a basis of evaluating the feasibility of deploying RFID technology at the selected postal operator.

KEY WORDS

RFID, container, transport unit, monitoring, logistics, identification

1. INTRODUCTION

Smart identification by automatic identification technologies currently plays an important role in all areas of the national economy. In terms of optimization of logistic processes, barcode technology is used. However, radio frequency identification technology brings lot of advantages to the table, therefore it is expected that its involvement will significantly expand into all areas of the national economy. The article focuses on research of RFID technology in the process of smart identification of containers trough RFID technology. It also talks about software support for RFID technology, mainly about creation and configuration of RFID middleware – specialized software tool allowing mutual communication between two or several applications; also known as connector between various application components. The article talks about RFID technology as well as about the completed study of readability of RFID identifiers placed on metal container. Among the results of the readability, the dependency of tags on the metal parts of the container has been studied. Based on the results of the research, a recommendation for tags positioning on container was published.

2. THE MAIN PRECONDITIONS AND TEHEORETICALLY BACKGROUND

The main precondition in conjunction with monitoring and identification of containers by passive RFID tags was, how the metal construction can interference readability of RFID tags and how it will change the value of RSSI. One of the other problems in dealing with projects related to the monitoring and control of containers, it is necessary to clarify and streamline the respective asset management. Other requirement is to ensure that the required amount of containers was always available at the right time and the right place [1]. All this plays an important role not only in the mass submitter that their shipments are inserted into a container in their own areas, but also for the processing and distribution centers of different levels where containers fulfills its fundamental role as a transportation unit. Monitoring and controlling the flow of containers should lead to the planned accumulation of containers for specific uses and preventing unplanned accumulation, which can lead to a shortage of containers in sorting and processing of the top resorts in the framework of processing postal operator. Besides this problem can insufficient monitoring (visibility) of containers cause of their loss and the subsequent cost of providing new containers [2], [3], [4]. Before starting our research, we were passed following the requirements of the proposed testing system:

- must provide an overview of used and underutilized postal containers,
- must provide an overview of the currently used postal containers (in terms of time and place),
- must provide an overview of the postal containers provided by the customer and returned to the top, of the top customers [5].

In general, our authority is assumed that the eventual implementation gains a tool that he will provide information for:

- preventing the accumulation mailing containers,
- minimize loss of postal containers,
- improving the accessibility of postal containers and ensuring the overall balance of the entire logistics chain,
- checking the contents of the mail containers,
- improving the postal service and maintenance of containers.

Of course, all these assumptions RFID technology can bring to incorrect implementation, which precedes the start of testing.

A. RFID Architecture

RFID technology is complex, combining a number of different computing and communications technologies to achieve desired objectives. Each object which has to be identified has a small object called a RFID tag stuck to it. Each RFID tag has a unique identifier that enables additional information about each object to be stored. Devices known as RFID readers wirelessly communicate with RFID tags, with a view to identifying the attached RFID tags, as well as enabling information stored in the RFID label to be read and updated.

Every RFID system contains an RF subsystem, and most RFID systems also contain an enterprise subsystem. An RFID systems supporting a supply chain is a common example of an

RFID system with an inter-enterprise. In a supply chain application, a tagged product is tracked throughout its life cycle, from manufacture to final purchase, and sometimes even afterwards (e.g., to support service agreements or specialized user applications). Radio frequency identification is a wireless data collection technology that uses electronic tags which store data, and tag readers which remotely retrieve data. It is a method of identifying objects and transferring information about the object's status via radio frequency waves to a host database. RFID represents a significant technological advancement in AIDC because it offers advantages that are not available in other AIDC systems such as barcodes. RFID offers these advantages because it relies on radio frequencies to transmit information rather than light, which is required for optical AIDC technologies. [4]

There are three basic components of RFID system: RFID tags, RFID readers and Middleware, which is responsible for all data transaction in the system.

An RFID tag (figure 1) is a small device that can be attached to an item, case, container, or pallet, so it can be identified and tracked. It is also called a transponder. The tag is composed of microchip and antenna. These elements are attached to a material called a substrate in order to create an inlay. Tags are categorized into three types based on the power source for communication and other functionality: active, passive, semi-passive and semi – active.

Figure 1 - RFID passive tag

The second component in a basic RFID system is the interrogator or reader (figure 2). Readers can have an integrated antenna, or the antenna can be separate. The antenna can be an integral part of the reader, or it can be a separate device. Handheld units are a combination reader/antenna, while larger systems usually separate the antennae from the readers. The reader retrieves the information from the RFID tag. [4]

Figure 2 - RFID reader

There is also Middleware, software that controls the reader and the data coming from the tags and moves them to other database systems. It carries out basic functions, such as filtering, integration and control of the reader. RFID systems work, if the reader antenna transmits radio signals. These signals are captured tag, which corresponds to the corresponding radio signal. [6]

B. Container monitoring

One of the main issues being addressed by the container tracking and managing project is need to take control of and better manage transportation assets. Another primary project requirement is to ensure that the required containers will be always available at the customers' premises and within postal operator facilities. This should overcome the tendency for planned or unplanned hoarding of containers that causes shortages elsewhere, especially at peak times. Additionally, the lack of visibility of container where about led to unnecessary loss since it was not possible to identify where the containers disappeared and hence forced expensive purchase of new containers to meet the customer service level agreements. [1],[2]

When a container is ready for dispatch, the container is scanned for destination and product type. If the container is lead through a gate not matching the destination, an alert will immediately help correct the mistake. Solution must include Asset Management software platform enabling full, real-time transparency of the location of each container and can be also used to track specific mail and parcel transports. [7]

Implementing this system offers unique values. Examples of benefits:

- improves availability and load balance throughout the logistics chain,
- prevents hoarding of containers,
- minimizes losses,
- helps to improve supply chain efficiency,
- provides the ability to monitor the transported delivery time of goods and
- helps to improve service and maintenance.

a. Postal transport network

Postal transportation network an operator is comprised of the following entities:

- the main processing centers,
- the local processing centers and
- the processing nodes.

The principle of distribution of postal containers is illustrated in figure 3.

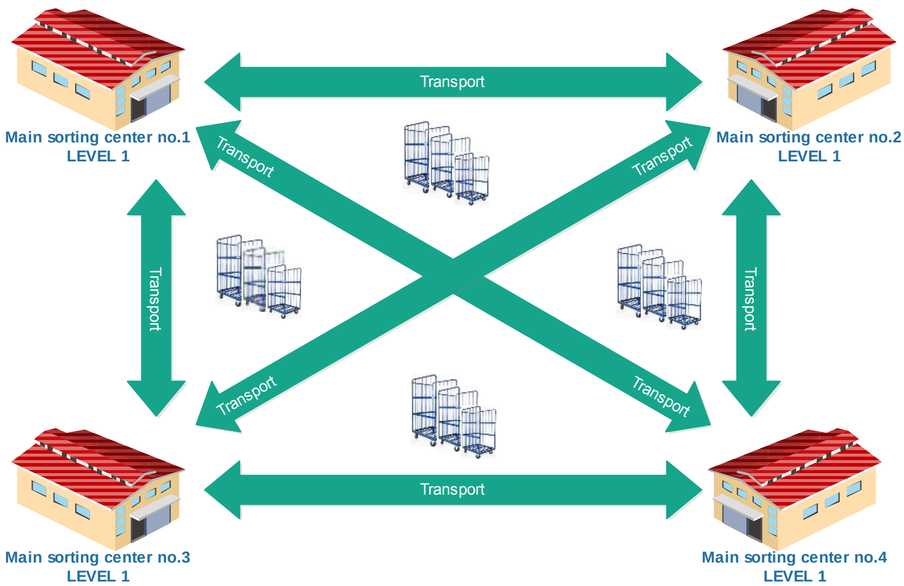

Figure 3 - The structure of postal transportation network

The main processing center performs sorting and processing mail, local processing center serves as front handlers for the main processing center and processing node acts as contact with top customers. Within the assigned area has always one main processing center, along with several local processing centers and processing nodes [5].

3. MEASUREMENT IN LABORATORY AND REAL CONDITIONS

In order to achieve relevant outcomes, it was inevitable at first to design functional system enabling realization of single measurements under laboratory conditions. In order to comprehend single measurements, we have to define the principle they operate under and what is being detected by them. We have to find out the readability of RFID tag placed on metal container at the moment of its passing through RFID gate with antennas. Considering the close collaboration of our department with company ATO spa. , we chose middleware OnID or AMP that actually made our work with collected date much easier.

A. Laboratory measurement

In the laboratory we conducted a series of tests on borrowed mail container from the postal operator. It was mainly a choice of RFID readers, RFID antennas, RFID tags and their placement on the mail container.

During the measurements were used omnidirectional antenna connected to the reader Motorolla FX 7400. RFID identifiers were scanned from above. The roll cage is made of steel and due to problems with loading the RFID identifier needs to be appropriate to the location of the antenna connected to the RFID reader. Equally important is also the location identifiers. Walls of the roll cage are formed by a metal grille which can have the effect of reducing the intensity of the signal reflected back from the identifier antenna. From many pre - tested RFID tags, we chose special encapsulated tags on metal (see Fig. 1).

The largest portion of the laboratory testing was devoted to placement of RFID antennas and RFID tag placement on the mail containers because these two parameters offered a fairly wide range of combinations. For the placement of RFID tags on the metal container we selected 25 positions (see Fig. 4) and these positions were tested laboratory condition. In terms of potential damage to the antenna by RFID containers, we finally chose the placement of antennas above the containers, as can be seen on the second part of Fig. 3. [7].

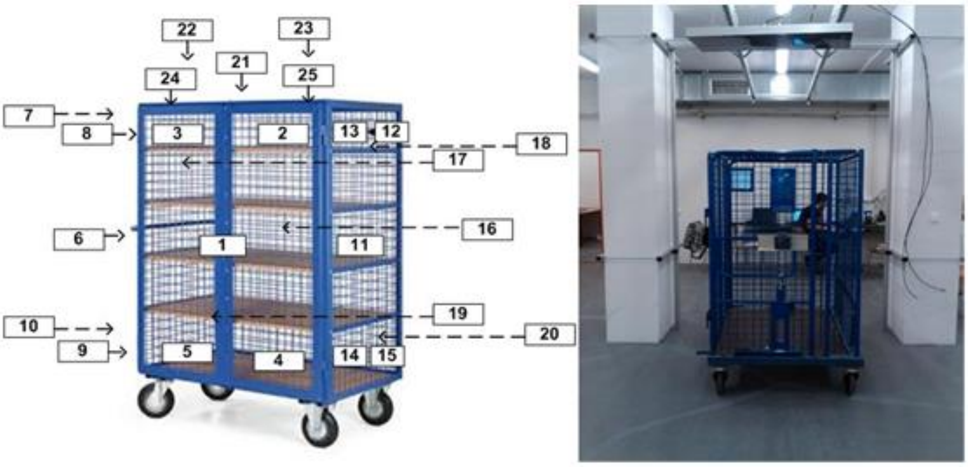

Figure 4 - Placement of RFID tags at postal container

3.1.1. AMP model configuration

Middleware AMP ensures communication between hardware and software part of our model. At the same time, it enables to set up the configuration itself, so by its use we define practically what, how and when should the particular hardware and software components operate.

Under the configuration shown in Figure 5 there are processors, including:

- LLRP reader - may represent a real goal sensing RFID identifiers or test goal, which only simulates loading identifiers.
- Whitelist - a list of ID individual identifiers, which are under testing process. Reader does not respond to identifiers that are not listed in the whitelist.
- DB - processor for recording information in the database.
- Test Device – Processor for simulation an RFID gate.
- EarlyDecoupler - this processor is used to filter the retrieved ID and avoids multiple load at the same identifier. The function of the processor includes a timing adjustment.
- Time formatter 1, 2 – this processors transforms timestamp coming from the RFID reader to selected format of the time, for example. YYYY-MM-DD or HH:MM:SS [5]

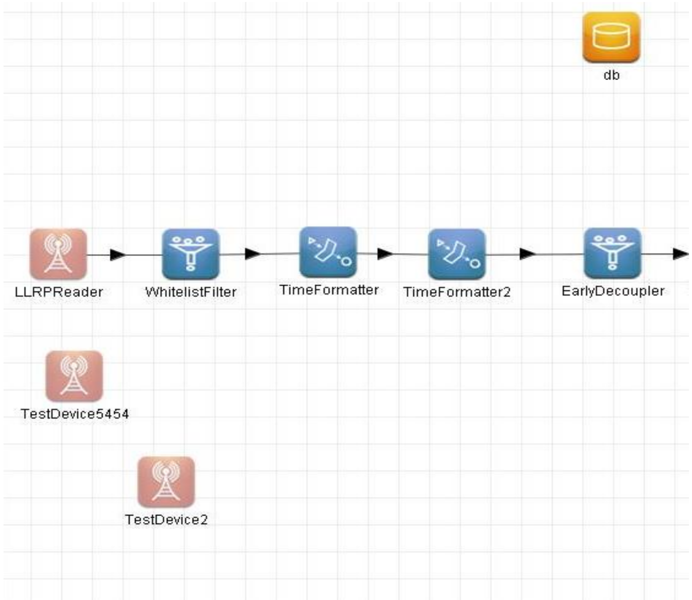

Figure 5 - AMP model configuration – first part [5]

The second part of the configuration see Figure 5, consists of processors to work with data that change the status of individual items in the database every time you load identifier. Other processors in the configuration of processors are used to format the dump to the console server java AMP:

- InlineSelectProcessor - It allows to load data from DB based on the input parameters for SQL demand.
- InsertProcessor – It allows to store data to the DB.
- XMLInjector (1, 2) – It allows to set constant to XML path.
- InsertProcessorJournal – It allows to store journal information from measurements.
- Logger – It allows to real time logging of measurement.
- Message morphing – It's used for transforming text to XML format.
- Message generator – It's used for generating XML messages.

Each processors have additional configuration parameters that can be set in conjunction with different purposes.

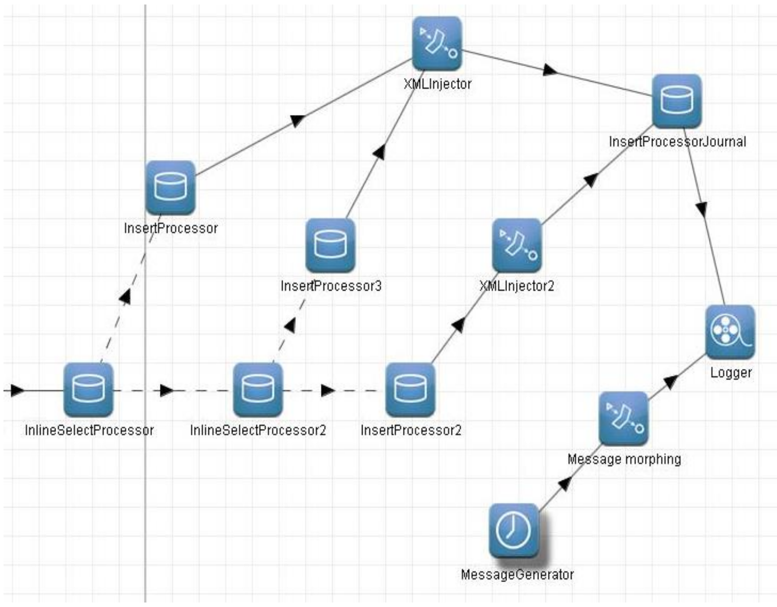

Figure 6 - AMP model configuration – second part [5]

3.1.2. Result of laboratory measurements

Selected RFID tag were measured on 25 different positions and we obtained not only values of readability of RFID tags but also strength of the backscattered signal value called RSSI. With this value (fig. 7) we were able to select right placement (fig. 8) of RFID tag on metal container.

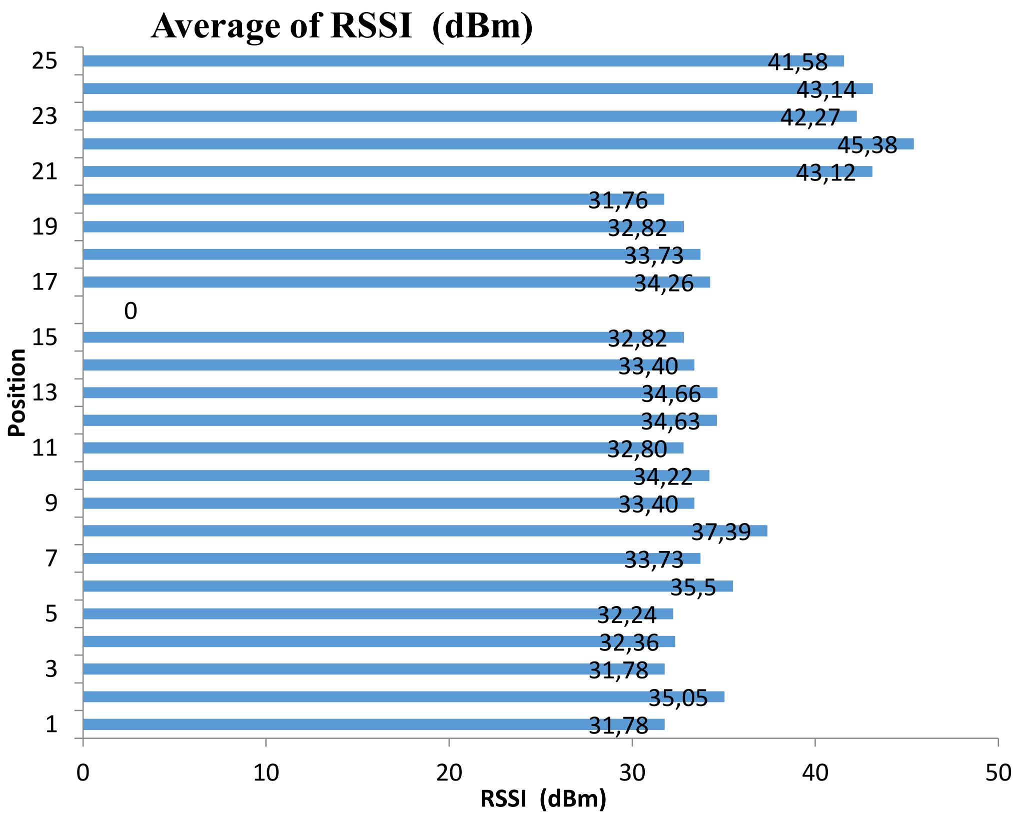

Figure 7 - Average of RSSI at selected placements of RFID tag [5]

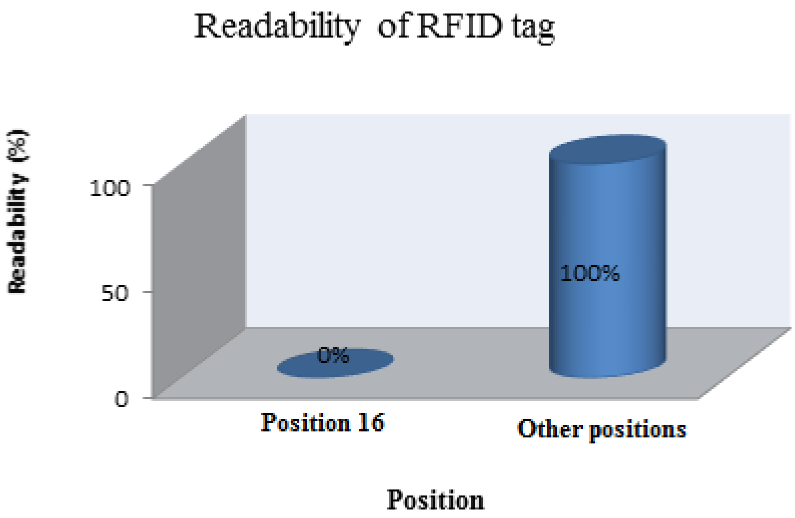

Figure 8 - Average of RSSI at selected placements of RFID tag [5]

From the result described on the figures above, we can see the value of RSSI by different position of RFID tag. Position 25- 21 achieved the best results. In relation to readability we can see that only position where the RFID tag was placed on position number 16 was not read by RFID reader. In terms of potential damage to the RFID tag antenna by units usually placed on the top of the RFID containers and other operational barriers we selected following position (fig. 9) and from this positions we chose position number 13, that obtained best RSSI value.

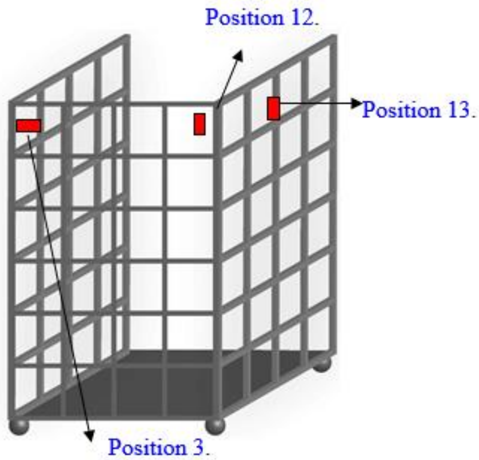

Figure 9 - Selected placement of RFID tags at postal container

a. Real testing

After we had finished a laboratory testing and evaluation, it was a time for real testing at condition in selected postal operator. Due to the nature postal transportation network it was decided that the testing will take place only on the part of postal transportation network. It was chosen the part of postal transportation network that meant in terms of RFID worst possible conditions. Every major, local processing center and processing segment are inherently different. This is due to the nature of the construction and processing area for loading and unloading. That is why we chose to test the worst possible conditions because it is more than likely that the same problem on other operations do not conflict. Overall, we are in the allocated area selected 3 Entities. These were main postal processing center, local processing center and processing node. Schema of transport between these entities are shown in Figure 10.

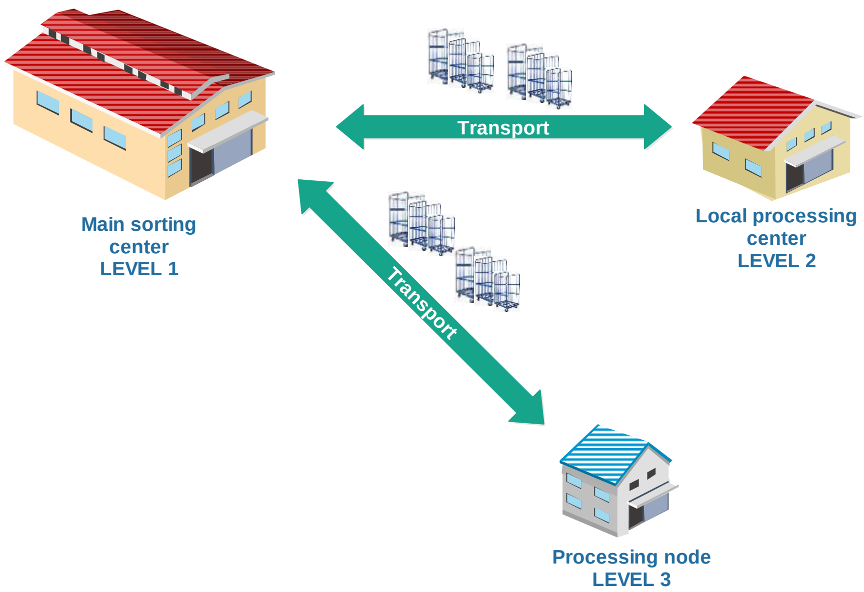

Figure 10 - The part of postal transport network

We have made a real application, which consists with web application that is shown on figure 6. Selected processing centers and nodes of postal operator were equipped with the aforementioned device. All readers are connected to the main database server via a mobile connection. RFID readers have been through middleware connected to a central database server and subsequently evaluated by means of web applications in real time.

The statistical web module has provided us with information about the length of time and transport time to stay on the individual processing centers for individual postal containers. Also, we monitored as individual sites provide postal containers and more.

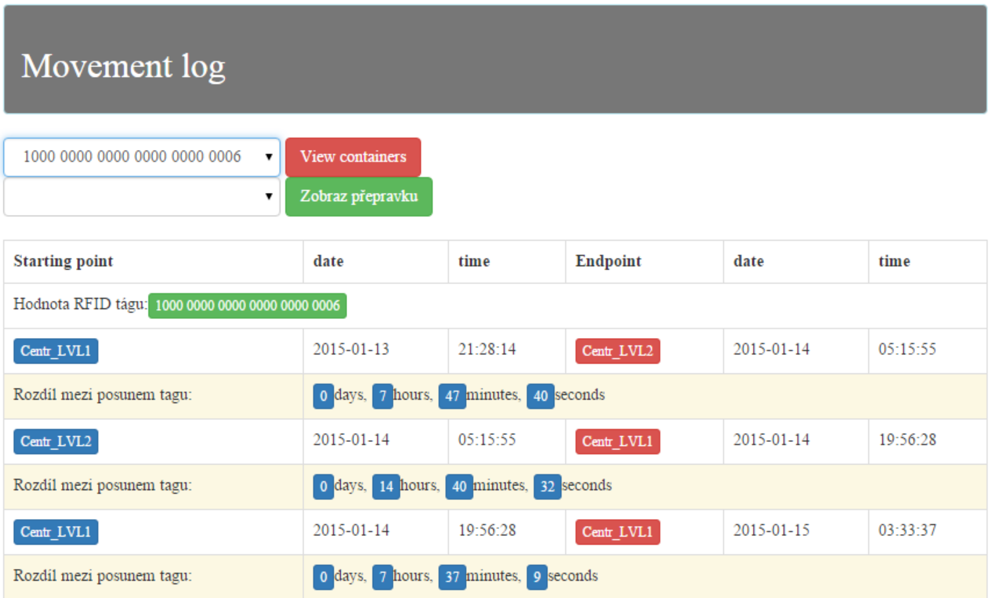

Figure 11 - Web application

The configuration implemented at one of the processing centers of postal operator can be seen in Fig. 12.

Figure 12 - Real configuration on postal operator

After installation of all modules in selected processing centers of postal operator, we placed RFID tags on all mail containers in selected mentioned processing centers. For several days the system record entries containers through our system. But after the interim and final evaluation of all the data collected, we were able to determine the exact results and opinion. We achieved 100% readability of all RFID tags, that were circulated around the selected processing centers.

4. CONCLUSION

We made a pilot in conjunction with postal operator and we got relevant information to designate a utilization of RFID implementation in postal environment in field of identification and monitoring postal containers and postal packages. We can say that our result in our configuration provide for postal operator a realistic view of the location of postal containers in real time.

This research represents another step towards the identification of the entire postal logistics chain and then connection to the concept internet of postal things (*IoPT*). In the implementation of RFID technology should take into account its advantages and disadvantages. The main advantage is the traceability of postal containers across the entire network. At disadvantages may be mentioned perhaps higher initial investment costs to build an RFID infrastructure. Each postal operator, after quantifying ROI must decide whether it pays to invest in this technology or not. The concept of IoPT is the basis for the implementation a whole range of new innovative next services and support process in postal market, for example, real time identification of packages and boxes.

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REFERENCES

[1] KEBO V., STAŠA P., BENEŠ F., ŠVUB J. RFID Technology in Logistics Processes. In SGEM 2013: 13th International Multidisciplinary Scientific GeoConference, Albena, Bulgaria, 2013, pp. 219-226.

[2] KUBASAKOVA I., KAMPF R., STOPKA O. Logistics information and communication technology. Communications, Scientific Letters of the University of Žilina, Vol. 16, No. 2, 2014, pp. 9-13.

[3] KENDRA M., LALINSKÁ J., ČAMAJ J. Optimalization of transport and logistics processes by simulation. In ISTEC: 3rd International Science, Technology and Engineering Conference, Dubai, United Arab Emirates (UAE), 2012, pp. 886-892.

[4] BUKOVÁ B., BRUMERČÍKOVÁ E., KOLAROVSZKI P. Zasielateľstvo a logistika. Zodpovedný redaktor: Mária Bali-Jenčíková. Bratislava: Wolters Kluwer, 2014.

[5] MADLEŇÁK R., MADLEŇÁKOVÁ L., ŠTEFUNKO J. The variant approach to the optimization of the postal transportation network in the conditions of the Slovak Republic. Transport and telecommunication, Vol. 16, No. 3, 2015, pp. 237-245.

[6] KOLÁŘ, P. Container shipping market dimensions and customer orientation in the Czech Republic. Central European Business Review. 2013.

[7] VACULÍK J., IVAN M., KOLAROVSZKI P. Principles of selection, implementation and utilization of RFID in supply chain management. PROMET-Traffic & Transportation, Vol. 21, No. 1, 2009, pp. 41-48.

[8] KOLÁŘ, P., RODRIGUE, J.-P. Improving the Bottlenecks: The Czech Republic as a Central European Intermodal Transport and Logistics Platform. In IAME Conference 2014. Norfolk: Maritime Institute, Old Dominion University, 2014.

[9] MASLARIĆ M, GROZNIK A, BRNJAC N. Distribution Channel Reengineering: A Case Study. PrometTraffic&Transportation. 2012;24(1):35-43.