Smart identification of roll cages through logistics chain

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Abstract: Article provides research in field of automatic identification of roll cages through radio-frequency identification technology (RFID) in terms of supply chain of particular postal-logistics operators. The ambition of this work is selection of appropriate identifier type and its placement on a roll cage. A special section is dedicated to description of the technical equipment used during measurements as well as their results from MySQL database. Article deals with relationship between the orientation of the antenna RFID identifier and orientation of the reader antenna and also the placement of the RFID identifier on the metal roll cage.

Keywords: RFID tag, Reading device, Automatic identification, Roll cage, Middleware.

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 roll cages 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 roll cage. Among the results of the readability, the dependency of tags on the metal parts of the roll cage has been studied. Based on the results of the research, a recommendation for tags positioning on items was published.

2. Theoretically background

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. [3]

2.1. RFID system

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]
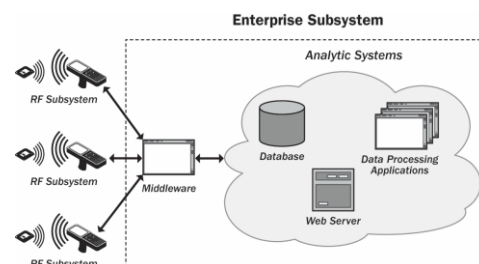

Figure 1. RFID system architecture

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 2)is a small device that can be attached to an item, case, roll cage, 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.
- Semi – active.

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Figure 2. RFID passive tag

The second component in a basic RFID system is the interrogator or reader (figure 3). 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 3. 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. [7]

2.2. Roll Cage Tracking and monitoring

One of the main issues being addressed by the roll cage 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 roll cages will be always available at the customers' premises and within postal operator facilities. This should overcome the tendency for planned or unplanned hoarding of roll cages that causes shortages elsewhere, especially at peak times.

Additionally, the lack of visibility of roll cage where about led to unnecessary loss since it was not possible to identify where the roll cages disappeared and hence forced expensive purchase of new roll cages to meet the customer service level agreements.[1][2]

When a roll cage is ready for dispatch, the roll cage is scanned for destination and product type. If the roll cage 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 roll cage and can be also used to track specific mail and parcel transports. [6]

- Implementing this system offers unique values. Examples of benefits:
- Improves availability and load balance throughout the logistics chain.
- Prevents hoarding of roll cages.
- Minimizes losses.
- Helps to improve supply chain efficiency.
- Provides the ability to monitor the transported delivery time of goods.
- Helps to improve service and maintenance.

## 3. Description of measurement for smart identification of roll cages

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 several type of RFID tags placed on metal roll cage (roll cage) 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.

3.1. 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 4 there are processors, including:

- LLRP reader - may represent a real goal sensing RFID identifiers or test goal, which only simulates
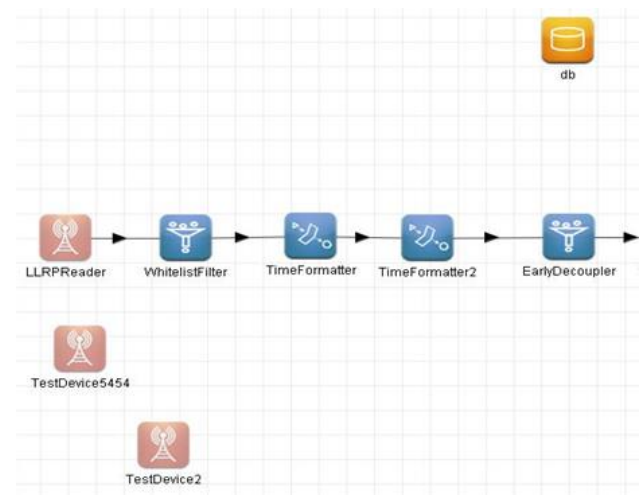
loading identifiers.
- Whitelist - a list of ID individual identifiers, which are under testing process. Reader does not respond to identifiers that are not listed in the whitelist.
- EarlyDecoupler - This processor is used to filter the retrieved ID and avoids multiple load at the same identifier. The function of the processor includes a timing adjustment. [5]

Figure 4. 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.

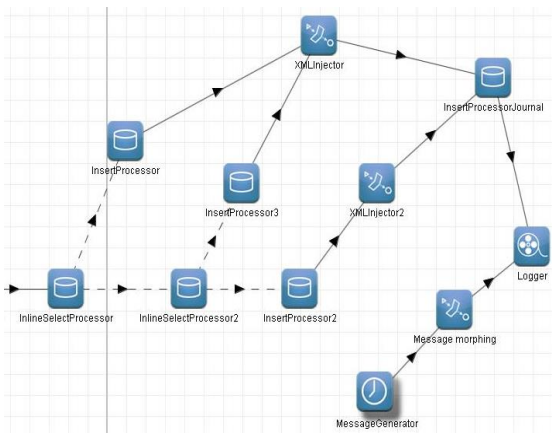**Figure 5.** AMP model configuration – second part [5]

Figure 6. AMP Java server console

3.2. Description of selected identifiers for measurement purpose

The measurements were carried out using various types of RFID identifiers. The first type used for the measurements was the most commonly used type identifiers shown in Figure 7. When we placing this type of identifiers directly on the construction of the roll cage there was a problem with readings, because of the nature of the roll cage material used for measurements.[8]

Figure 7. RFID identifiers number 11 [5

Construction of the roll cage used during the measurement is made of steel that is of a conductive material. The readability of this type identifiers can be increased using a non-conductive spacers.

Another type of RFID identifiers used in the measurement is more resistant to mechanical damage and weathering. Ensures undoubtedly the plastic cover identifier is shown in Figure 8. The price of this type of identifier is however higher compared to first type.

Figure 8. RFID identifiers number 22 [5]

A third type of resistance is comparable to the previous type. Chip and the antenna in this type of rubber is inserted into the housing, which allows good handling of the identifier in its strengthening. The difference is in the process of consolidating for the roll cage. This type of identifiers is shown in the following figure. [5]

Figure 9. RFID identifiers number 31 [5]

3.3. Description of the measurements

During the measurements were used four omnidirectional antennas 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.

At the beginning of the measurement, it was necessary to choose the appropriate identifiers, which was done in test measurement. Based on the results of the test measurements were carried out additional measurements.

The measurements were carried out using five identifiers of the first type, the three identifiers of the second type and one RFID identifiers of third type described above. During tests and real measurements were used two antennas, which were placed on top, which is also shown in the figure below. Individual identifiers were thus scanned from above. Black plastic cover shown in the figure10 has incorporated the two antennas of the reader.

Figure 10. Location of RFID antennas [5]

4. Result of measurements

To achieve real results in the real measurements we used four different locations of RFID identifiers placed on the walls of the metal roll cage.

1. Placement of RFID identifiers on the front wall of the roll cage.
2. Placement of RFID identifiers on the side wall of the roll cage.
3. Placement of RFID identifiers on the top wall of the roll cage.
4. Placement of RFID identifiers on the bottom of the roll cage

Placement of RFID identifiers on the front wall of the roll cage.

Individual RFID identifiers were in the first measurement placed on the front wall of the roll cage (figure 11).

Figure 11. Placement of identifiers in measurement 1 [5]

During the first measurement were used two antennas located at the top, just like in the test measurement and three RFID identifiers of different types. The number of repetitions of this type of measurement we set to 100. Results of the first measurements show the suitability of the second and third type of RFID identifiers. RFID identifier no. 22 achieved 100% of readability and identifier number 31 with 97% of readability. Identifier no. 11 was reached only 23 times of 100 measurements. Clear graphical representation of the results of the first measurement is illustrated in Figure 12.
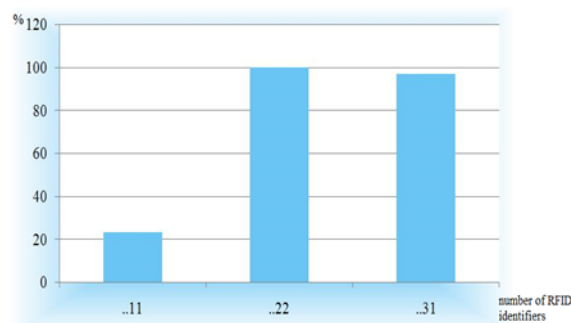

Figure 12. Readability of RFID identifiers at the first measurement

4.1. Placement of RFID identifiers on the side wall of the roll cage.

By second measurement was assessed readability of selected three types RFID identifiers placed on the side wall of the roll cage. The course of the second measurement was similar to that in the previous case. Different placement of identifiers resulted in varying percentage of readability. Identifier no. 11 was not read and identifier no. 31 achieved 42%. For the second type of identifier (no. 22) we achieved again 100% of readability (figure 13).
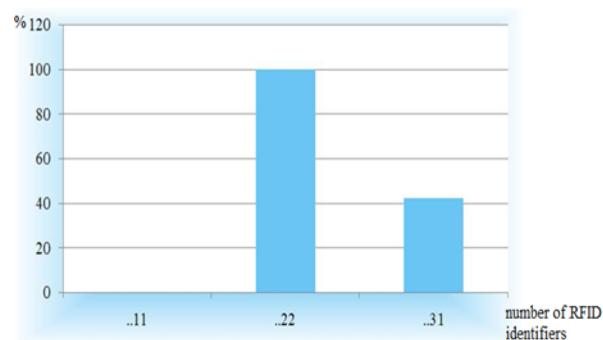

Figure 13. Readability of RFID identifiers at the second measurement

Identifier no. 11 showed zero readability. This was due to the orientation of the antenna identifier to the orientation of the antenna of the reader. Identifier placed on the side wall of the roll cage had an antenna oriented almost perpendicular to the reader antenna, which did not allow to read this type of identifier.

4.2. Placement of RFID identifiers on the top wall of the roll cage.

Placement of RFID identifiers in the third measurement was on the top wall of the roll cage and is shown in the following figure.

Placement identifiers on the top wall of the roll cage resulted in a high percentage of readability for the first, second and third type of identifier. The first type identifier for this measurement showed a high readability (97%). This was due to the orientation of the antenna identifier to the orientation of the antenna of the reader. In this case it was the appropriate orientation of the antenna identifier considering to the antenna of the reader. The following figure graphically represents readability of individual identifiers.

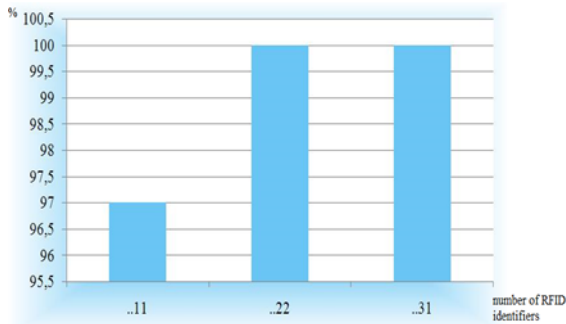**Figure 14.** Placement of identifiers in measurement 3 [5]

Figure 15. Readability of RFID identifiers at the third measurement

4.3. Placement of RFID identifiers on the bottom of the roll cage

Identifiers for the fourth measurement were placed at the bottom of the roll cage, as shown in the following figure.

Figure 16. Placement of identifiers in measurement 4 [5

Placement identifiers at the bottom of the roll cage resulted in varying percentage loading in the first and third type of identifier. First type of RFID identifiers achieved 83% and third type 62% of readability. For the second type, we obtained the same results as in previous measurements. This identifier reached 100% of readability. [5]

Figure 17. Readability of RFID identifiers at the fourth measurement

5. Conclusion

We can state that introduction of passive radio frequency identification of items in logistic operation is technically feasible as a very high level of readability was achieved by scanning of particular items under laboratory conditions.

The results of measurement show the relationship between the orientation of the antenna RFID identifier and orientation of the reader antenna and also the placement of the RFID identifier on the metal roll cage. The second type of identifier obtained in all measurements 100% of readability. Based on the results of measurements is this type of RFID identifier the most appropriate for smart identification of roll cages through logistics chain. The other two types of RFID identifiers reached erratic and insufficient values of readability and therefore are not recommended for the identification of roll cages.

References

[1] M. Kendra, J. Lalinská, J. Čamaj. "Optimalization of transport and logistics processes by simulation". In ISTEC Proceedings of the 3rd International Science, Technology and Engineering Conference, Dubai, United Arab Emirates (UAE), December 13-15, 2012 (pp. 886-892). ISSN 2116-7383

[2] J. Tengler, J. Vaculík: "Notification of delivery postal mail trough mobile phone".In: POSTPOINT 2013 „Delivering innovation and training in postal technology and services": Rajecké Teplice, Slovakia, 19.-20. september 2013 : - Žilina: Žilinská univerzita, 2013. - ISBN 978-80-554-0747-0. 189-196.

[3] V. Kebo, P. Staša, F. Beneš, J. Švub: "RFID Technology in Logistics Processes"; Proceedings of the 13th International Multidisciplinary Scientific GeoConference SGEM 2013, Albena, Bulgaria; ISBN: 978-954-91818-9-0

[4] K. Finkenzeller:" RFID Handbook: Fundamentals and Applications in Contactless Smart Cards, Radio Frequency Identification and Near-Field Communication". UK: John Wiley & Sons, Ltd.., 2010. 40 s. ISBN 978-0470695067

[5] P. Paľuv: "Identifikácia poštových kontajnerov prostredníctvom technológie RFID" Žilinská univerzita v Žiline. Fakulta prevádzky a ekonomiky dopravy a spojov; Katedra spojov, 2013.

[6] Z. Kocur, V. Machula, J. Kulda, L. Vojtěch : Analysis of Influence of Disturbance Level on Data Transmission in Wireless Networks. In TSP 2010 - 33rd International Conference on Telecommunications and Signal Processing. Budapest: Asszisztencia Szervező Kft., 2010, p. 292-296. ISBN 978-963-88981-0-4

[7] L. Vojtěch, M. Neruda : Application of Shielding Textiles for Increasing Safety Airborne Systems - Limitation of GSM Interference. In The Ninth International Conference on

Networks (ICN 2010). Los Alamitos: IEEE Computer Society, 2010, p. 157-161. ISBN 978-0-7695-3979-9.

[8] J. Lalinská, J. Čamaj, M. Kendra: Prenos inovačných poznatkov a technológií v logistických a dopravných procesoch. /Transfer of innovation knowledge and technologies in the logistics and transport processes/ In: Book of abstracts from Conference NITT SK 2013 - Technology transfer in Slovakia and abroad: Bratislava 8.10.2013. - Bratislava: CVTI SR, 2013. - ISBN 978-80-89354-18-4. - S. 37..