AUTOMATIC IDENTIFICATION TECHNOLOGIES WITHIN DISTRIBUTION LOGISTICS FROM THE PERSPECTIVE OF EFFICIENCY OF THE IDENTIFICATION PROCESS

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Abstract

This article deals with the use of automatic identification technologies within distribution logistics. Effective set up distribution logistics makes a significant contribution to improving the customer service of companies. Nowadays, when the importance of e-commerce is growing, it is necessary to efficiently set up logistics processes and use appropriate technologies. The "last mile" distribution is essential from the perspective of distribution logistics. It is the last stage in the distribution of consignments to the final customer from the distribution centres. In terms of automatic identification technologies barcodes are mainly used currently, but also quick response codes are increasingly popular. However, there are other automatic identification technologies, such as radio frequency identification technology. Radio frequency identification technology enables to get real, accurate, and timely data that is needed for effective distribution. The aim of this article is to compare selected parameters of the efficiency of the automatic identification process of consignments within distribution logistics. Experimental testing of selected automatic identification technologies was carried out in a specialized laboratory of automatic identification.

Key words: automatic identification technologies, distribution logistics, radio frequency identification technology

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Introduction

Distribution logistics include the freight transport and warehousing system layout that serves to move goods between production and consumption points. Right products in the right amount and right quality must be shipped in the right place, at the right time and for the right price to the right final customer. This must be achieved while maintaining the highest possible

level of customer service and the lowest possible cost. This is one of the reasons why companies are constantly improving distribution logistics processes and investing in modern technology. Implementing automatic identification technologies within distribution logistics is a way, how to increase customer service levels.

1 Theoretical Background

In the context of globalization, many new international trade and transport flows have emerged over the past decades, representing major logistical challenges in distribution logistics (Onstein et al. 2019). The distribution logistics setting significantly influences the distribution speed and distribution efficiency (Wang, 2019). Effective distribution logistics occurs when using suitable modern technologies of automatic identification. Typical automatic identification technologies used in distribution logistics are:

- Bar codes.
- Quick Response codes (hereinafter QR codes).
- Radio Frequency Identification (hereinafter RFID).

European Article Numbering 13 (hereinafter EAN-13) is a linear, numerical and continuous code that is intended primarily for the rapid identification of goods. The code can store 13 digits. Each digit being coded by two lines and two spaces. Each group of digits has its meaning. The first three digits indicate the country of origin, the other four to six digits determine the manufacturer, and the following digits determine the specific product. The last digit is a check and it is used to verify that the decoding is correct. EAN-13 is the most used barcode, which was defined by not-for-profit organisation GS1. The code is a key to the external database from which the product-related data is displayed (GS1, 2019).

QR code is a code developed by the Japanese company Toyota. It consists of square cells and allows omnidirectional and very fast loading of large volumes of data. The code includes three characteristic symbols, which are used to orient the reader and thus enable fast reading of data. The QR code can encode numeric characters, alphanumeric characters, and binary data (Gaben, 2019).

RFID technology has been used in a wide range of applications since the 1950s (Sundberg et al., 2018). Nowadays, RFID is beginning to develop and be used extensively in a variety of industries, especially where speed and accuracy of information is emphasized and then transmitted by corporate software for further reporting (Kong et al., 2015). RFID uses information carriers, so-called tags, readers and software to process information.

The big advantage of RFID is that there is no need for direct visual contact to retrieve tag information (Huang and Lv, 2018). For example, a tag can be stored in a package, and the reader can read it even at a greater distance depending on the performance of the reader. This leads to great timesaving as well as cost savings for the company (Yong et al., 2017). Accuracy with RFID means that due to the appropriate layout of the readers (antennas), the movements of packages, devices or employees can be monitored with great precision. Thanks to this, many companies use RFID, for example in goods handling warehouses (Kong et al., 2015). RFID visibility and traceability is a viable intervention in reducing logistics costs (Hardgrave et al., 2013; Wang et al., 2018).

Unfortunately, RFID technology is still a relatively expensive technology for which quite high initial investments are required. It uses a wireless communication based on the principle of electromagnetic wave reflection. The big difference from other wireless technologies is that the reader is a wave transmitter and the RFID tag is a signal receiver. Instead of transmitting its own signals, the tag only modulates or reflects electromagnetic waves from the transmitter (passive tags). This technology has the undoubted advantage of not requiring a complex tag design, but only a small, simple tag that is neither technologically nor financially expensive to produce. This cannot be said about the complexity of the reader, which is structurally somewhat more complicated and expensive to purchase. RFID tagging has proven to be effective in transport and logistics studies (Williams et al., 2019; Liébault et al., 2012; Bradley and Tucker, 2012). The aim of this article is to compare selected parameters of the efficiency of the automatic identification process of consignments within distribution logistics.

2 Methods

Experimental measurements are used in terms of scientific methods in the specialized laboratory of automatic identification located at the Faculty of Transport Engineering, University of Pardubice.

The aim of experimental measurements is to compare selected parameters of the efficiency of the automatic identification process of consignments within distribution logistics. The first parameter is a load time. This parameter is defined as a time of loading consignments with a given technology. The second parameter is the reading distance. This parameter is defined as the required distance between the reader and consignments to ensure consignments reading.

Experimental measurements were performed using the following automatic identification technologies used in distribution logistics and theoretically described in the first chapter of this scientific article:

- Bar codes (EAN-13).
- QR codes.
- RFID.

The sample of used EAN-13 codes, QR codes and RFID UHF tags ALN-9654 "G" Inlay in the experimental measurements is shown in Fig. 1. These bar codes and QR codes were chosen because of their frequent use in tracking consignments within distribution logistics. The size of used codes (EAN-13 and QR) corresponds to the GS1 standards, which are recommended for distribution logistics processes.

RFID UHF tag ALN-9654 "G" Inlay was chosen because of its suitability for distribution logistics processes. This type of tag is designed for use on glass, plastics, wood, or other challenging insulator materials. RFID UHF tag ALN-9654 "G" Inlay supports protocols ISO/IEC 18000-6C and EPCglobal Class 1 Gen 2. The tag specification is as follows: EPCglobal Certificate 950110126000001084, operating frequency 840–960 MHz, EPC Size 96–480 Bits and user memory about 512 Bits (Alien Technology, 2019).

Fig. 1: EAN-13 code, QR code and RFID UHF tag ALN-9654 "G" Inlay used in the experimental measurements

Source: Alien Technology (2019); authors

Experimental measurements of the efficiency of the identification process of consignments within distribution logistics were performed in the specialized laboratory of automatic identification using a transport cage where the consignments were placed (six plastic crates and one paper crate). Each consignment was tagged with one RFID UHF tag ALN-9654 "G" Inlay, QR code and barcode (Fig. 1).

The reader CipherLab CP30 WM 6.5 Pro, 2D Imager, BT, Wi-Fi, 3G WCDMA, GSM, GPRS, EDGE, WQVGA was used to read the barcodes and QR codes. The RFID system

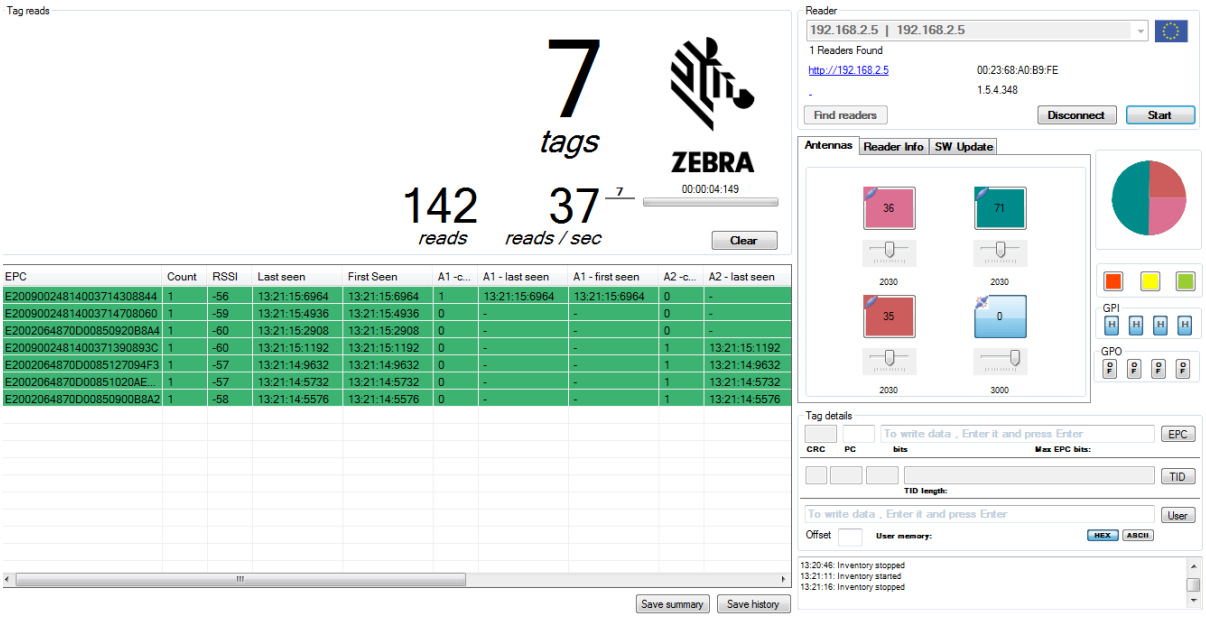
consisted of the following components: fix reader Motorola FX9500, RFID antennas AN480, connecting cables, notebook including SessionOne software for device discovery, inventory operations, access operations, export tags, and map and show pictures to tag IDs. The RFID system operated at UHF frequency (850 MHz – 950 MHz). This frequency is suitable for RFID applications in the transport sector for tracking containers, consignments and pallets (GS1, 2019).

Five people realized experimental measurements. Each person made twenty measurements, and a total of one hundred independent measurements were realized for each automatic identification technology. The measured data were arithmetically averaged. This data was used for evaluation of load time and reading distance of the analysed automatic identification technologies.

3 Results and Discussion

Load time for RFID technology was evaluated using software SessionOne (Fig. 2). This software evaluates reader and antenna data. The software visualizes the tag EPC number, the number of reads per time unit, the time of the first and last read of the tag by each antenna and the value of the received signal strength indicator (RSSI). RSSI is a measurement of the power received from the returned signal from the RFID tag when interrogated by a reader.

Fig. 2: Software SessionOne (experimental measurement sample no. 52)

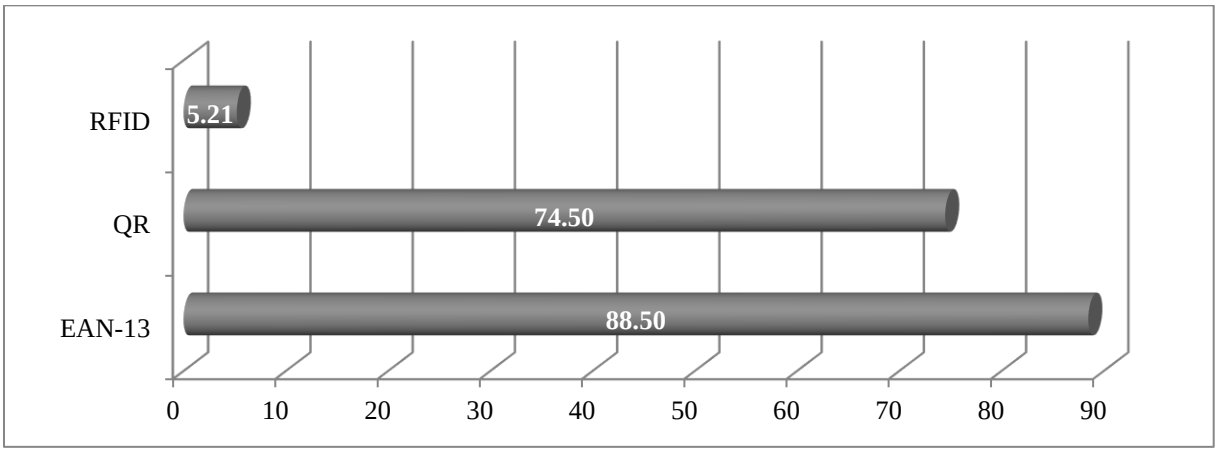


Source: authors

Load time for other automatic identification technologies (barcodes and QR codes) was measured by the stopwatches by two independent observers.

The results of average load time are presented in Fig. 3. The average load time of consignments using RFID technology was 5.21 seconds. This time was fourteen times shorter than using QR codes and seventeen times shorter than using barcodes, because the average load time of consignments using QR codes was 74.50 seconds and for barcodes, it was 88.50 seconds. RFID technology is clearly the fastest in terms of consignments load time. The difference in load time of consignments between RFID technology and barcodes or QR codes is 69 to 83 seconds. If more than seven consignments were used for experimental measurements, the barcode or QR code load time would increase significantly compared to load time using RFID technology. This is one of the basic advantages of using RFID technology – a short tag load time. This advantage can be crucial to streamline distribution logistics processes. The average barcode and QR code load time is very similar because the code loading procedure is the same. The only difference in terms of loading code lies in the loaded object. QR codes are becoming increasingly popular compared to barcodes, mainly because they allow encoding more data nowadays, in the context of distribution logistics processes.

Fig. 3: Consignments average load time for selected automatic identification technologies [s]



Source: authors

The second experimental tested parameter was reading distance. The RFID system was set to a standard reading distance of 1.5 m. This reading distance is consistent with the UHF frequency, which makes it possible to read tags over a distance of meters. The reading distance for barcodes and QR codes was based on the results of experimental

measurements averaged over 0.4 m. The experimental measurement results show that the required distance between the reader and the consignments to ensure consignments reading is over 0.4 m. This reading distance already ensures that consignments codes are loaded.

The results of the experimental measurement confirmed the specific advantages of using RFID technology in the distribution logistics processes. An essential advantage of RFID technology lies in the fact that all tags (consignments) are read together at one time point. Due to this fact the consignments load time using RFID technology is faster. The results of the experimental measurement showed that the loading time of the consignments using RFID technology was fourteen times shorter than using QR codes and seventeen times shorter than using barcodes. This is also influenced by the separated scanning of barcodes and QR codes. This causes the extension of the consignment load time. The advantage of RFID technology, which lies in the simultaneous loading of multiple consignments, is associated with the additional advantage that RFID technology ensures that all consignments containing RFID tags are read. If using a manual scanning technology for barcodes and QR codes, an operator can easily forget (overlook) any of the consignments.

The advantage of RFID technology lies also in reduction or elimination of the manual labour. In a situation where a static RFID system (RFID gate with antennas) is used, it is not necessary for the operator to read individual consignments because they are automatically loaded by the RFID system. The employee only needs to ensure the flow of consignments through the RFID gate. On the other hand, it is possible, for example, to use a belt conveyor that ensures a smooth flow of consignments through the RFID gate. When loading barcodes and QR codes, it will always be necessary to ensure employees who will scan individual consignments and load them into the system. It is possible to state based on the results of the experimental measurement of the analysed parameters (load time and reading distance) that the most suitable automatic identification technology from the perspective of efficiency of the identification process is RFID technology. RFID technology has also other specific advantages associated with lower consignment load error rates or lower manual effort.

The limits of the performed experimental measurement are mainly related to the time of loading the consignments. The working environment and technical equipment have a great impact (type of used antennas and readers, tag type, barcode and QR code size, lighting and laboratory noise). An important aspect is also the people who carried out experimental testing of selected automatic identification technologies. In fact, the following factors can play an important role: training, style of work, physical condition, experience, motivation. The effort of this experimental measurement was an effort to eliminate these limits.

It was simulated an environment that matches the conditions in logistics distribution centres in the automated identification laboratory. The standard equipment was used, the same as one used in logistics distribution centres in terms of automatic identification technologies. Selected tags, barcodes and QR codes are normally used in distribution logistics processes. Workers who conducted experimental measurements were intentionally of different sex, age and education.

Conclusion

The aim of this article was to compare selected parameters of the efficiency of the identification process of consignments within distribution logistics. Two parameters tested in this research were selected – the load time of consignments and the reading distance of the automatic identification technologies. Experimental testing of selected automatic identification technologies was carried out in a specialized laboratory of automatic identification. RFID technology, barcodes and QR codes were tested.

RFID technology was evaluated as the best to ensure efficient of distribution logistics processes of consignments based on experimental measurement of the analysed parameters. On the other hand, RFID technology has higher investment costs than barcodes and QR codes. RFID technology is effective in a situation where it is implemented in the entire supply chain at the same time. Supply chain entities are constantly striving to streamline distribution logistics processes because they are directly linked to the level of provided customer service. The use of automatic identification technologies is one way to achieve this streamlining.

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