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TRANSPORT UNITS IDENTIFICATION IN THE TRANSMISSION PROCESSES IN POSTAL SECTOR THROUGH RFID TECHNOLOGY

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This article primarily deals with identification of postal items and transport units in the logistic chain of postal operators. Nowadays, the identification is carried through barcodes and optical character recognition. In this article we would like to specify, how the transport units can be identified in the transmission process by RFID technology. In the carriage of postal items it is necessary to decide what type of transport is used for that purpose, what the flows of items are and what their intensity is. The RFID technology is complex, combining a number of different computing and communication technologies to achieve the desired objectives. Each object, which has to be identified, is stuck inside of a small object known as an RFID tag. RFID tag has a unique identifier, through which you can store additional information about the object. Equipments which are known under the name of RFID readers wirelessly, communicate with RFID tags with a view to identify RFID tags attached as well as the possibility to read and update information stored in the RFID label.

The article describes the scheme of the transport process, including planned technology and there is also simulated a real postal process in conditions close to operational.

Keywords: RFID technology, Transport unit, Transportation, Postal items

Introduction

An unavoidable part of today is a dynamic development in the field of mobile technologies, their everyday use and application of the processes, which largely support the level of the quality of postal services and thereby strengthen the market positions of individual postal operators. This area is even more pertinent that in all countries of the European Union since 1 January 2013 approved the postal market and postal services. In this respect, it is necessary to include the postal processes embarked on new technologies to ensure the competitiveness of the national postal operator and the alternative providers.

RFID technology has been selected by an international post corporation (IPC) to test deliverability (transit time) of items in 55 countries of the world (Slovak republic including). The requirement of transit time is defined by the Universal Postal Services and applicable also for Slovak Post. Despite the RFID technology is being known and being improved for a long time, it is essential to define the standards and security requirements.

Besides efficiency, consolidation and globalization within the European Union, interoperability is one of key elements. It is the ability of information and communication systems (including the supported processes) to exchange data, share information and knowledge, which lead to standardization.

1. Objective and Methodology

To understand the problem it is appropriate to analyze the various terms used. With the current availability of individual components of RFID, GPS devices and the possible use of the possibilities of satellite navigation, we can create quite a purposeful infrastructure and improve the traffic management of the postal processes.

Despite the fact that the personal correspondence is given to the development of information technologies and the Internet on the decline and supporting interest in use of the postal services to business correspondence, the postal services are and will remain an essential part of the society.

Taking into account all these contexts, external influences on the postal sector and the potential of the existing technologies from the perspective of the thesis it is important to analyze the possibilities for automation of the processes, streamlining operational activities and transportation to ensure continuity in meeting the objectives of customer satisfaction in the field of postal services, particularly in the delivery of consignments. The paper defines and points out the possible improvements in this area.

1.1. Mobile Technology

The classification of wireless technologies, based on the distance or range of the transmitted signals, provides insight into their potential use. Condition for the data transmission in the wireless systems and communication networks is not fixed connection cable. One possible distribution system is under the coverage:

- **Global Systems** – cover wide scale spatial coverage, it is possible to talk about the world operating systems, which are not dependent on the particular application and data transfer takes place in various protocols (eg, the satellite communication systems, GPS);
- **Metropolitan systems** – operate in a lower geographical unit, usually on the national level (such as systems based on the microwave technology, WiFi);
  Local systems – ranging from the order of centimeters to hundreds of meters (Bluetooth, RFID).

1.2. Postal Transport Network

The postal transport is an important part of the process of filing a postal item to its delivery to the addressee in compliance with established quality standards for different types of mail under postal license requirements and the quality of universal postal service.

The postal transmission network consists of the road transport routs and road itinerary. The structures of the postal transmission network use various tools and systems. The postal transport network is currently divided into three main levels:

- district transport network (OPS) – connects the establishment and other facilities on the territory of the district processing center and regional units (OU) with the delivery points,
- regional transport network (RPS) – connects the main processing centers in regional processing centers with their own circuit, the main processing centers with appropriate regional nodes, where the regional processing centers are,
- the main transport network (HPS) – connects the major processing centers, the main processing centers with regional processing centers from another circuit HSS, including the transport findings in the international relations.

In the carriage of postal items it is necessary to decide what type of transport is used for that purpose, what are the flows of items and what is their intensity. The way to connect and the type of the vehicle depend on the following factors:

- density and organization of the postal network,
- flows of different types of postal items and their size,
- the carrying capacity of the vehicles used,
- transport time of each species of postal items,
- safety and effectiveness of the postal traffic.

Processing of items is implemented in the workplace of the Slovak Post:

- HSS – the main processing center – the facility providing treatment and quest items posting its area of perimeter, mail items addressed to your district and in transit in its dealings with OSS circuit, in contact with other HSS and OU,
- OSS – the regional processing center – the post office responsible for preparing and quest items posted at post offices in his own constituency and in transit in contact with your postal district and interacted with the HSS, the facility responsible for receiving, processing and questing items express postal services,
- selected post – the post office responsible for preparing and questing items selected species within a specified range (usually as OSS),
- Exchange post – processing the shipment and ensuring shipments to post offices exchange foreign postal administrations,
  Regional hub as a department of express service – establishment is responsible for receiving, processing and questing items express postal service.

1.3. Characteristics of Transport Units and Processes

Characteristics of transport units – Slovak Post, a. s. used in the transport process shipments following shipping units: containers, leaf containers and postal bags. Containers are used in the transport process at HSS and OSS, on the local network using only postal letter case and postal bags.

The basic flows of transport processes are shown in figure 1 including the use of a basic mobile technology on the relevant stages.

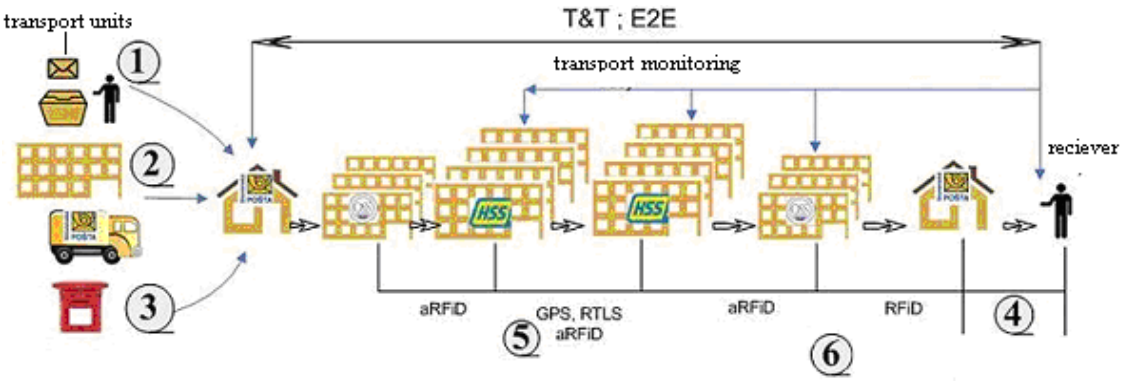


Figure 1. Scheme of the transport process, including the planned technology

1. sender pass the post office at the counter,
2. collecting expedition posting or accumulating courses,
3. pass through postal box,
4. mobile technology – monitoring the transport process ,
5. possibilities for optimizing routes for mail delivery,
6. communication with the addressee.

2. RFID Technology

Radio frequency identification is a wireless data collection technology that uses the electronic tags which store the data, and the tag readers which remotely retrieve the data. It is a method of identifying the objects and transferring information about the object status via the radio frequency waves to a host database. RFID is not necessarily a direct replacement for the bar codes, but as the costs of RFID systems continue to decrease, the functional utility of RFID will greatly surpass that of bar codes. [7]

An RFID system is a set of components that work together to capture, integrate, and utilize data and information. This section describes some of them. The components are as follows:

- Sensors, Tags, Antennae, Readers.
- Connectors, Cables, Networks, Controllers.
- Data, Software, Information Services.

2.1. RFID Tags

An RFID tag 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. [8]

Tags are categorized into three types basing on the power source for communication and other functionality.

- Active.
- Passive.
- Semi-passive.
- Semi-active.

2.2. RFID Reader

The second component in a basic RFID system is an *interrogator* or *reader* (Figure 4). Readers can have an integrated antenna, or 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 of reader/antenna, while the larger

systems usually separate the antennae from the readers. The reader retrieves the information from the RFID tag. The reader may be self-contained and record the information internally; however, it may also be a part of a localized system such as a POS cash register, a large Local Area Network (LAN), or a Wide Area Network (WAN). [6]

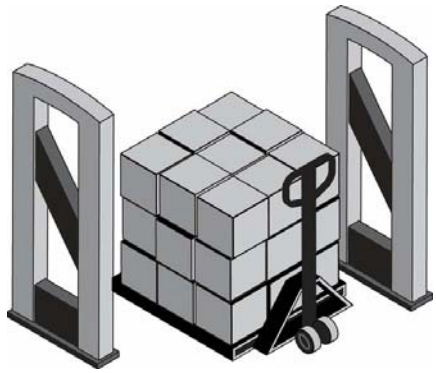


Figure 2. Stable RFID reader

3. Model and Test of Readability of Postal Items through the RFID Technology

One of the methods that could significantly make the process of identifying the postal items in transport condition effective is just a RFID technology. As a wireless technology, without visual contact with the shipment, it tracks and identifies the contents without the need of manual handling from the crate. This allows easier and more efficient handling of supporting documents (creating the list of items, checking the presence of item) of postal sacks/bags and containers. With regard to price and the quantity of item processes, a question arrives: Is RFID technology effective and should be used for all shipment, including letters? As it has already been mentioned, due to the large quantities of common items and still relatively high price of tags the method could be real only for the registered mail. The actual implementation design of RFID technology, as shown in Figure 3 could be divided into the following phases:

1st phase – tracking between the HSS
2nd phase – tracking between the HSS and OSS.
3rd phase – tracking between the OSS and final post office (point of delivery).

Because of the fact that our basic interest lies in the RFID technology we have tried to test the readability of the RFID tags placed on the postal items in various situations. The basic assumption is the use of RFID gates at the entrance and output of the processing unit as it is shown in the following figure.

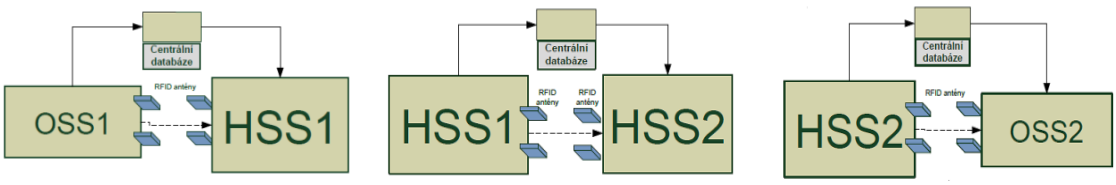


Figure 3. RFID gates at the entrance and output of the processing unit

In order to verify the practical applicability of this technology, we have dealt with the preparation and implementation of the practical activities through which we have examined reading RFID tags. The objective of these measurements was to determine the statistical characteristics of reading success and reading passive tags, placed on postal items, located in the mail bag. The aim was to provide sufficient information, accurately measured under the different conditions that can occur in a real situation, including a draft measure, which would lead to the improvement of the measured data.

Therefore, we try to simulate a real postal process in conditions close to the operational ones, and test this technology on next component set configuration:

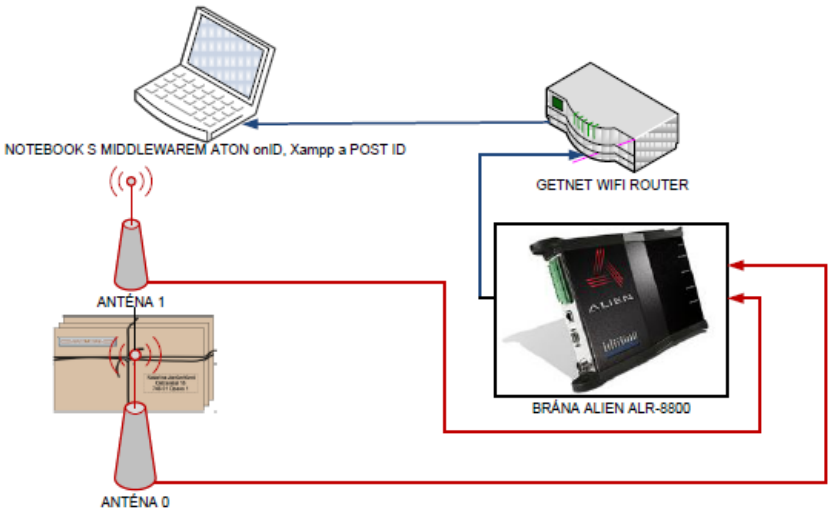


Figure 4. Principle component links

When entering the volume or volumes placed in the transport unit to the detector array there is a transfer of identification data of RFID tags through the RFID gate antennae in which the process and with further data. These data, the number of antennae in particular, have a specific identifier and retrieve the operational information in the form of door type. Thus the processed data are transmitted through the wifi router middleware Aton on Id in a notebook.

Here is primarily the communication between web applications POST ID, MySQL database server and middleware on id Aton. The principle of the software components and their cooperation can be understood from the figure located in next section.

3.1. Description of the Model

There was used a software from Italian company Aton, also known as a middleware, which provides the management, organizational and communication operations between different applications. In our case, they are the firmware Alien Gate and other applications, particularly database server. On id Aton itself is not a monolithic program, but it is a functional connection Java service console (java server) and the graphic manager called Qflow. Qflow itself is intuitively and easyly enabled in an interactive creation and administration of the custom processes.

The major elements are the program elements, called the processor to implement elementary operations (reading from the gateway, filtering, recording the output, etc.)

- The first step is to enter the configuration data to POST ID. From there it must be deposited directly into the database tables. The subject of this storage is data on the number of configuration items and numbers.
- In a second step, after the start of broadcasting the alien elements and their detection by Inline Procesor, load measurement numbers, the number of items and the configuration numbers are made and then they are attached to the information from the antennae.
- The third step is to report the detection of these data; it enriches the timing parameters through the Time Formatter processors, and cumulative data travel up to 4 lines. The first two travel into the generators of the text and xml files according to the uniqueness of the registration data. The third way is into the InsertProcessor, where the data are entered into the database. The fourth way turns itself to the LackEvents processor. In case if there is no new messages from the gateway recorded in the determined period of time, it sends a new message to next two processors, which increase the value of the measurement number by 1 on the basis of the received message (MessageGenerator) by updating the database InsertProcessorA.
- The second Command Executor processor on the receipt of a report indicates the new number of measurements by running the alarm. The measurement consists of setting values in POST ID and physical adjustment of antennae. There has been an effort done for making sure if it is possible to have the most accurate and smoothest possible transition from beginning to end of the runway. After making the transition it is necessary to wait for the time needed for detection of zero, which means the CPU and Lack Events Command Executor sounds, indicating the end of the measurement and readiness for the next measurement. At the same time, the processor Message

Counter increases the number of the first measurement after finishing the sound detection, and it is possible to make the switch between the antennae to the selected track again.

Full application part is shown in Fig. 5

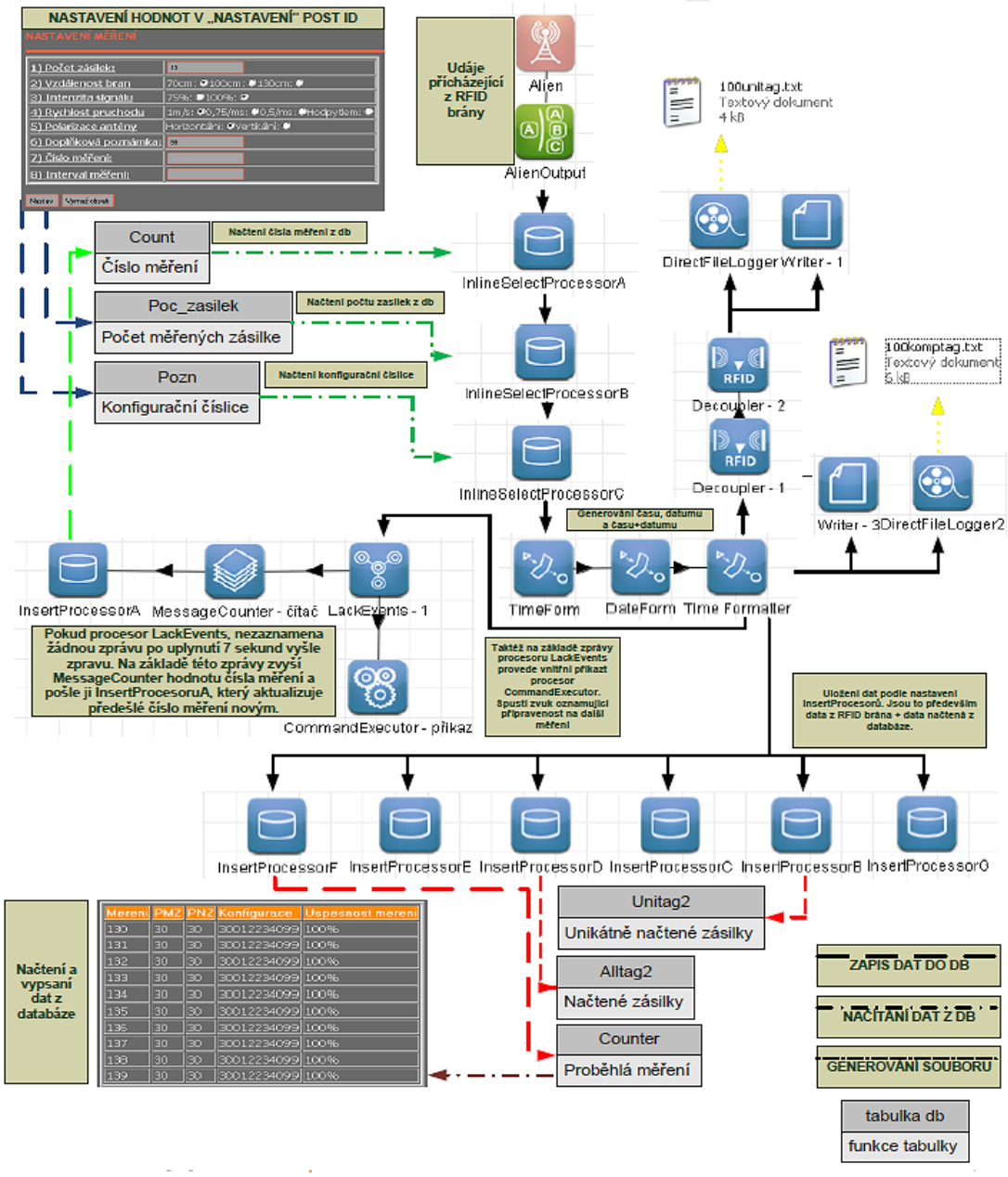


Figure 5. Final configuration model based on ATON on ID

3.2. Test of Readability of Postal Items

Measurements have been carried out in an improvised laboratory in the premises of the computer lab of the University of Žilina. There were measured the passive tags placed uniformly on all mail in the middle of the upper left corner. Tags were placed so strictly because the challenging situation that could occur in real practice was simulated, so that all shipments under the labels overlap, the close neighbours. This arrangement could cause the EM waves emitted by RFID tags to interfere with each other. For each item there was then transcribed a RFID tag number and a serial number marked for easier later processing the statistical information. The objects of the measurement items were deposited into the mail bags, which

are grouped into a bundle. To determine the characteristics of reading and expanding, sub-measure was introduced by another character, and that is the position of the beam due to the antennae. These positions are defined (according to Figure 6):

1) boundle horizontally – the length of the area enclosing antennae,
2) boundle horizontally – the width of the area enclosing antennae,
3) boundle vertically – party address shipments parallel flat antennae,
4) boundle vertically – mail address side perpendicular to the plane antenna.

Likewise, our measurements were sequenced according to the serial number of items, grouped into bundles, according to the size of the consignments as shown in Figure 7.

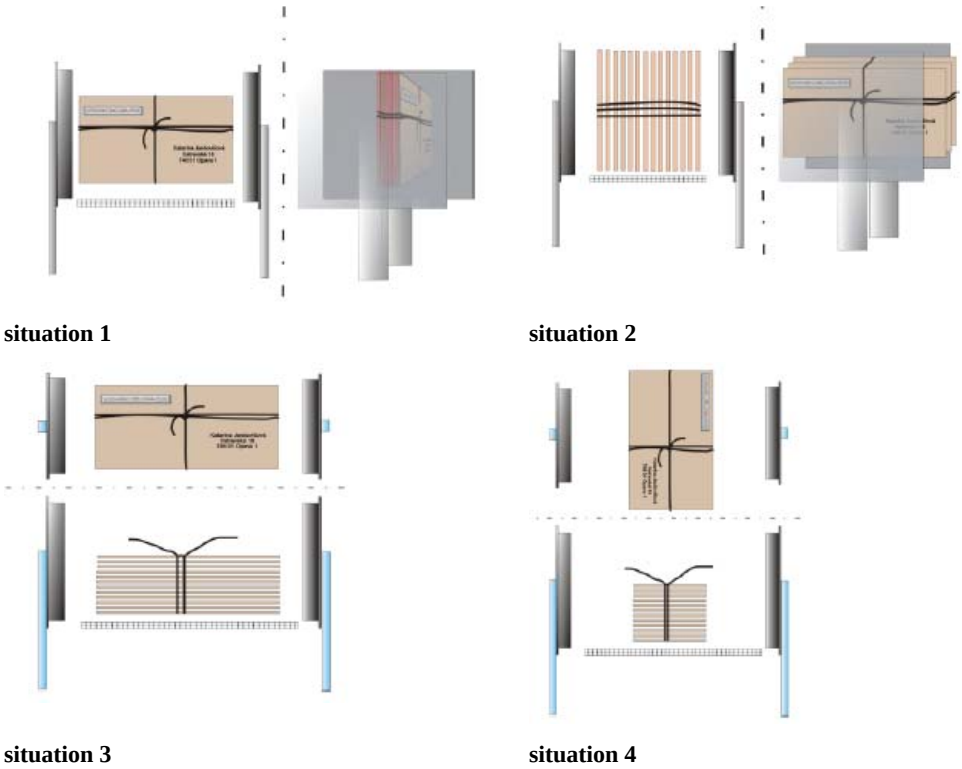


Figure 6. Configurations of the letters bundles

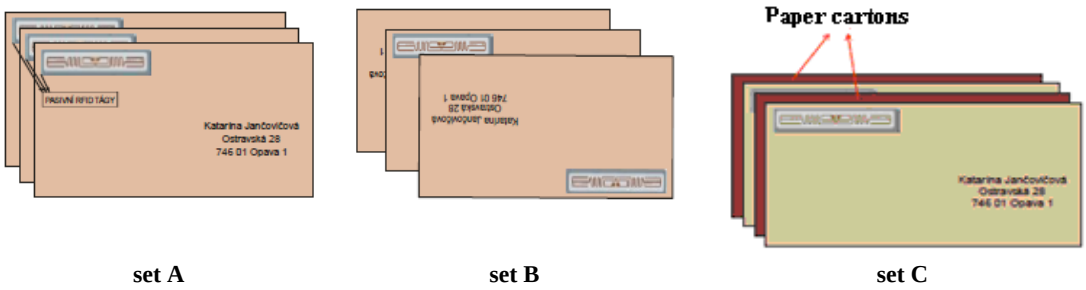


Figure 7. Several sets of the letter bundles

We have used two ways of transporting items via the gate:

1. Static transfer through the postal truck or conveyor, also examined the transport unit volumes, which are in a relative peace in terms of positioning items
2. Dynamic hand, respectively the manual transfer using human power – move with a rate shocks, which could help to read the labels in bundles better.

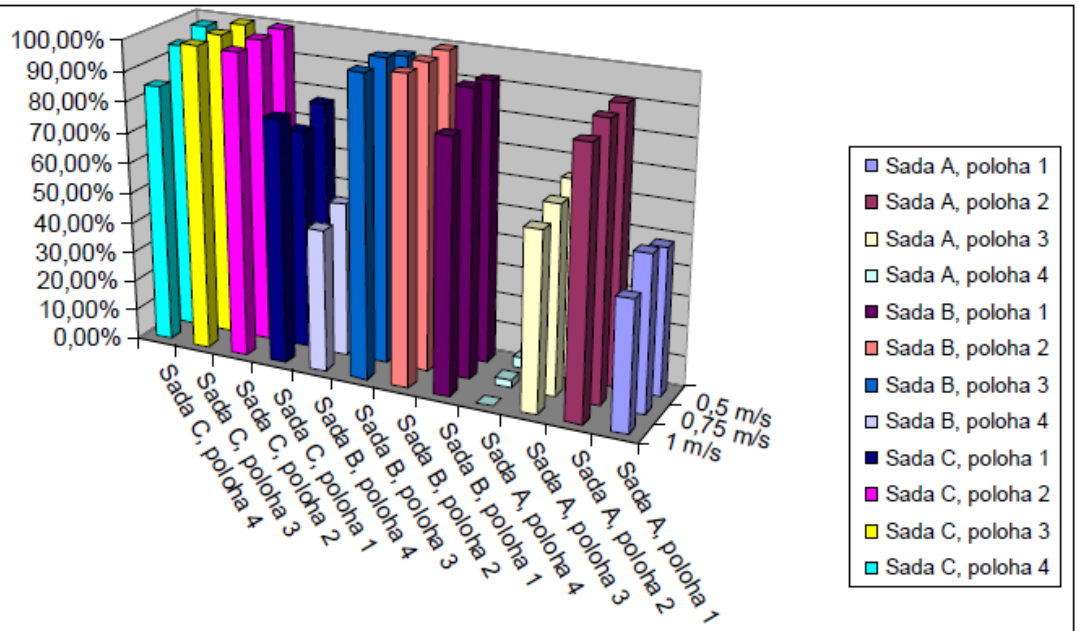
All the data recorded after the measurement time have become the subject of evaluation, and because of the large scale of the recorded data, there have been evaluated only the average and the

cumulative results. Determining the accuracy of measurements based on the statistical characteristics - it is a statistical description, which expresses the degree of statistical variability of the file, it indicates the letter R, It indicates the difference between the largest and smallest value and in some extent we are able to denounce both the large inaccuracies in the measurement occurred. It is expressed by the formula $R = X_{\max} - X_{\min}$. In percentage terms inaccuracies modified formula looks as follows:

$$Z = ((X_{\max} - X_{\min}) / number\_of\_items) * 100$$

Basing on this formula, inaccuracies sets were compiled by chart positions.

Since the evaluation of this quantity of data with the graphic processing is substantially opaque (a sample can be figure 8 with a graphical evaluation, which is a preview of kits depending on the speed of transition between the antennae) and it is not possible to present all the results of the measurements on such a small space, only the basic results of the measurements have been summed up and the authors have focused only on some important findings.



	1 m/s	0,75 m/s	0,5 m/s
Sada A, poloha 1	42,56%	51,28%	48,21%
Sada A, poloha 2	87,18%	90,26%	90,77%
Sada A, poloha 3	58,97%	62,05%	65,13%
Sada A, poloha 4	0,00%	2,56%	3,59%
Sada B, poloha 1	83,08%	93,85%	92,31%
Sada B, poloha 2	100,00%	100,00%	100,00%
Sada B, poloha 3	98,46%	99,49%	96,41%
Sada B, poloha 4	46,67%	50,77%	55,90%
Sada C, poloha 1	80,51%	72,31%	77,44%
Sada C, poloha 2	99,49%	100,00%	100,00%
Sada C, poloha 3	100,00%	100,00%	100,00%
Sada C, poloha 4	85,13%	94,87%	97,95%

Figure 8. Final test results

The measurement is made clear that some parameters are irrelevant in terms of readability, such as the speed of shipments run through the transition zone, readers are relatively independent (readability in

an average of about 76% to 2% deviation, the readers distance is taken with a 77% deviation around 6% use conveyor with 80% deviation around 4%, or manual switch (94% with a deviation of about 2%).

Table 1. Basic dependency between the sets of readability and the situations

Set	situation 1	situation 2	situation 3	situation 4	average
A	47,35%	89,40%	62,05%	2,05%	50,2%
B	89,74%	**100,00%**	98,12%	51,11%	84,7%
C	76,75%	99,83%	**100,00%**	92,65%	92,3%

It is interesting that in an evaluation of readability situations of the consignment the given readers run through the gate (table 1 upper part), in some cases it is sufficient and relatively uniformed (situation 2 and 3, value of 100%), while situation 4 is, for example, the readership in wide range of 2% up 92%.

The overall success of the method of transition as the distance of antennae for different speed ranges from 81%–87%, and has a major impact on readability, similar to the way the transition between the sets of antennae is relative stable (81% to 95%)

Basing on the evaluation of the measurement data cannot be identified unambiguously, excluded or recommend for the use of this technology in practice. These measurements may be partly conditional on imprecision caused by a provisional Laboratories. It is unable to clearly provide the desired stable speed and position of shipments due to the antenna. The end result is, therefore, the lack of readability of RFID tags in a traditional way-now commonly used in practice in the post measurements, known as set A. Although in other cases, the readability is very high and almost 100% (set C or B), there are other aspects that significantly affect its use.

4. Conclusion

RFID is a very useful and exciting technology. It seems that everywhere one looks there is some article about RFID and the huge benefits, which are promised by this technology. Moreover, there are many examples that demonstrate how this technology is fulfilling its potential.

Basing on the measurements it can be concluded, with some exceptions that prove the rule, the closer they are to each antenna, the greater the success of reading RFID tags. Given the large dispersion of values it can be concluded that some elements are simply eliminated. They can, for example use the multiple counting gates, respectively antennae (eliminating the position of shipments), or the use of such specialty (bubble) envelopes for magnification air gap between consignments (as by set C)

This article deals with the identification of the postal items and transport units in logistic chain of postal operators. It has described the scheme of the transport process, including the planned technology and there is also a real postal process simulated in conditions close to operational. The article is a part of the projects described above, which, together with the afore-mentioned applications, are able to improve the learning process at the Department of Communications.

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KEGA 077-059ŽU-4/2010 *"Implementácia nových technológií do vzdelávania (vytvorenie RFID laboratória ako podporného prvku pre vzdelávanie)" - "Implementation of new technologies in education (create RFID lab in support of both education)"*
KEGA 089-068ŽU-4/2010 *"Aplikácia RFID pri sledovaní pohybu diplomových a bakalárskych prác v rámci univerzitného campusu" - "Application of RFID in tracking Theses within the university campus"*
Centre of Excellence for systems and intelligent transport II (048/2009/2.1/OPVaV, Aktivita 1.4) – ITMS 26220120050

References

1. Hunt V. D., Puglia A., Puglia M., RFID: *A Guide to Radio Frequency Identification*, ISBN-13: 978-04701072007.
2. Kolarovszki, P., Vaculík, J. Real process of automatic identification items and services and transfer of knowledge – RFID LAB. *In Pošta, Telekomunikácie a Elektronický obchod. [online]*, 2010, ISSN 1336-8281.

3. Švadlenka L. A KOL. Transportation and communication system, *První vydání. Pardubice: Univerzita Pardubice*, 2006. 136 s. ISBN 80 – 7194 – 911 – 6
4. Švadlenka, LIBOR. RFID in postal and courier services. *In PRASAD, B. V. S., KALAI, Selvan. Supply chain management in services industry : an introduction.* 1st edition. Hyderabad (India): Icfai Books, 2007. s. 68-74. ISBN 81-314-0756-X.
5. Thornton, F. A KOL. *RFID Security, Rockland* Syngres Publishing 2006. ISBN 1-59749-047-4.
6. Tengler J. Identification of postal items through RFID technology, *diploma paper, University of Žilina*, 2010. 77 s
7. Zelik P. Mobile technology in postal transport, University of Žilina, Faculty of Economic and Operation of Transport and Communication, *thesis*