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RFID Scenario Application

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Abstract. Nowadays, implementations of RFID are growing. More and more trade enterprises are using RFID and other wireless technologies. In case of RFID, there are different implementation forms. RFID can be used widely, but before using it, enterprises must make some changes. In addition, investments are required. Such could be a barrier to implement RFID, especially for medium and small size trade enterprises. The target of such study is to identify the opportunities how the implementation of RFID, can help to reduce costs. To determine potential costs savings, Interactive warehouse simulation model is used. The study results show that the costs can be significantly minimised when RFID is implemented. In addition, some theoretical investigations regarding RFID implementation in logistics are also presented in the paper.

Keywords: RFID, logistics of trade enterprise, warehouse, forklifts, savings.

1. Introduction

RFID is not a new technology - it has been around since the 1940s. The technology has been used by the military and other organizations with special needs as an advanced system. In 1970 the technology was started to be applied for identification using the barcodes (Burinskiene 2008). In late 1980s RFID was introduced in industrial applications (Ollivier 1995). The diffusion of the technology has gone slowly, partly because of high implementation and operational costs (Rogers 2003; Holmqvist et al. 2006).

RFID is one of automatic identification (Auto-ID) technologies. Auto-ID technologies have the following advantages: fast data transmission speed, fewer

manual operations, bigger control and management, greater accuracy and productivity. These technologies help organizations to manage information more efficiently and to reduce costs of operations. Auto-ID technologies consist of the object identification and data communication elements. Object identification may be performed using barcodes, worker cards, speech, etc. automatically. Information about the identified object is transferred to database wherein data is accumulated and stored (Burinskiene 2008). For data transferring electronic network is used. The research of Eurostat (2006) shows that 37 % of trade organizations (mainly medium and large size organizations) are using local networks in Lithuania (Eurostat 2006).

Auto-ID technologies can be used in different sectors for identification of:

- Credit and debit card is used in finance sector;
- Items is used in retail sector;
- Pallets and places is used in logistics and trade sectors;
- Truck is used in transport sector. Terminals mounted at yard can provide information about trailer movements (about trailer arrival and dispatch);
- Voice is used in pharmacy and trade sectors;
- Employees can be used in all sectors.

In today's world, there are various Auto-ID technologies for collecting data. Automatic data collection is a common term used for method, which helps in collecting information from processes with minimum manual efforts. Today's information systems make easier the collection of information. In addition, the analysis of scientific automatic data collection enables large-scale information collection without human errors. The benefits of automatic data collection include improved data accuracy, more rapid availability, better managerial decisions, improved workers performance and improved response rate to changes, etc. (Varila et al. 2007).

The benefits due to the application of Auto-ID technologies fall into the following categories:

- The speed of transactions are immediate in both ways: to and from information management system;
- No paper operations: the printing, distribution and handling of paper is eliminated;
- The control of operations: the operations and workers can be tracked on a real time (on-line) basis;
- Increase of productivity.

The analysis of scientific literature published by Oxford University Press, Cambridge University Press, Harvard University Press, Springer, M. E. Sharpe,

Routledge, etc. shows that by presenting Auto-ID authors focus more on logistics issue than on trade, pharmacy or finance issues. In numbers, 0.17 % of the authors, which are analysing Auto-ID focus on logistics issues and 0.01 % authors are examining the feasibility of Auto-ID in logistics. In addition, close results are received for RFID: by presenting RFID authors focus first on logistics issue, less on trade, finance and pharmacy issues (in sequence order). And in numbers, the analysis of scientific literature published by famous world publishers shows that 2.44 % of the authors, which are analysing RFID focus on logistics issues and 0.08 % of authors are examining the feasibility of RFID applications in logistics.

Talking about RFID application in logistics, one of less discussed topic is RFID application in warehouse. Most of the authors are examining the feasibility of RFID in transport and less of them the feasibility of RFID in warehouses.

2. The conception of RFID in logistics

Wholesalers and/ or retailers have the need to track assets, loading units and have the, data about their movements on-line. This would provide information necessary to identify potential targets for cost reductions, to assess new technology investments and to focus on the general management of all assets. Increased data collection does not often come for free. The data collection that would be required means increased costs (Varila et al. 2007).

RFID is used in distribution centres to facilitate two ways information exchange. The application is in:

- Real-time communication with material handlers,
- Updating instructions and priorities on real time basis,
- Two ways communication of information: one way goes information about task, another way goes confirmation that task is fulfilled (Ailawadi et al. 2005).

For these technologies to be used enterprises have to have compatible network and infrastructure (Wi-Fi devices) in place (Lorchirachoonkul et al. 2010).

The maximum reliable distance between the Wi-Fi devices is highly dependent on their technical parameters and environmental conditions – it can vary from a few dozen meters to hundreds of kilometres (Ubiquiti Networks 2017).

Wi-Fi technology ensures maximum data transfer rate which depends on the standard (for example, the 802.11b standard-compatible device can theoretically

send / receive 11 Mbps (or with 802.11n compliant device – 300 Mbps data stream). Maximum user data transfer rate in practice usually does not exceed 50 % of the excess of the theoretical line and data transmission protocols, and effect on the environment. Wi-Fi support is installed in all the most popular operating systems; wireless communication equipment is match with many of today's portable and handheld computers, even some mobile phones.

Advantages and disadvantages of Wi-Fi technology:

- Wi-Fi allows (in distance) to connect to a computer equipped with a network access point (access point);
- Wi-Fi allows users to move along, without losing the connection – Wi-Fi device with the ability to automatically connect to another access point if the first is no longer available;
- Wi-Fi allows you to expand Wi-Fi networks quickly and inexpensively;
- Unlike packet radio communication systems, Wi-Fi uses unlicensed radio frequency band for what users do not need to get licence from the Communications Regulatory Authority;
- Wi-Fi provides a secure transmission of information only when wireless network security protocols (WPA, WPA2) are used;
- Wireless communications using radio frequency spectrum band can be overcome by too much extraneous radio noise (e.g. interference generated by a radio telephone), which may affect the quality of communication (data transmission speed);
- No need for licenses. Unlicensed radio frequency band limits in different countries may differ on what wireless device is adapted to one world region (e.g., compatible with European Union standards) may not be coordinated with a similar device to another world region (e.g. USA);
- Wi-Fi competes with other technologies (e.g., WiMAX (when mobile devices can send / receive till 100 Mbps) and Bluetooth) (Communications Regulatory Authority of Lithuania 2017).

The initial considerations, then, and how you build the business case, and what kinds of results you might expect, are important. What factors contribute to the estimated benefits and investments? As the potential gain increases, it is more likely that the technology is going to be used across in warehouse. RFID represent a significant business transformation, this means that change management becomes an essential tool. As the price of technological equipment falls, the number of potential applications multiplies and the data requirements alone could place serious demands on a firm’s infrastructure for RFID (Mo et al. 2009), particularly if it must be functional 24 hours a day seven days a week

and the data is not being evaluated and acted upon locally rather being transmitted to a central location for analysis and action (Spekman et al. 2006).

The infrastructure needed for a firm to incorporate and handle the full potential of RFID has to be well developed. Different technologies, from readers to servers, needed for RFID implementation, are widely available. However, that is needed the ability of enterprise to be able to incorporate the application of RFID which is needed into its systems processes-effectively (Kumar et al. 2009). When enterprise is moving from paper-based process to RFID-based process, many changes have to be taken. One of them is implementation of reliable infrastructure, which supports RFID.

3. RFID application area – warehouse

Warehouse receives products in pallets, put them to reserve storage or pick places, then picks them and sends them to customers. RFID can be used anywhere in warehouse operations. Basically where there is a need to get information or where the paper is used in operations. RFID equipment has the capacity to store larger amounts of information and can read new information fast (Anonymous 2005). Reader is essentially a small computer with an IP address. A lightweight operating system is used to interface each reader to a transmitter, which then relay the information to the rest of the network (Lorchirachoonkul et al. 2010). The system's components control the flow of data from antenna to readers to transmitter and so on (Spekman et al. 2006).

There are traditional activities with an indication of how the RFID technology can be used:

- Receiving activity. RFID can be used for identification of pallets at the receiving docks. They can help to get real time (on-line) information about received items and quantities;
- Put-away activity. RFID can be used for identification of locations and can help to get dynamic data about stocks in locations. This gives real time (on-line) updates on stock availability in the reserve and pick locations or information about pallets, which are moved from one door to another and are ready to be shipped;
- Replenishment activity. RFID can be used to increase control on stock availability at locations and to eliminate no stock (out-of stock) problems. Automatic replenishment activity not new, but the usage of RFID can help to improve the accuracy of the process (Lorchirachoonkul et al. 2010);
- Picking activity. RFID can be used when orders of several customers

from single pick location are picked at the same time;

- Shipping activity. RFID can be used shipping pallets. After loading to truck operations were finished the dispatch manifests are generated.

The benefits due to RFID usage are flexible, speedier and paperless operations, improved control, productivity, higher accuracy and reduced costs in warehouse operations.

Talking about costs, Kok et al. (2008) suggest comparing the cases with and without RFID in terms of costs (Kok et al. 2008).

Accuracy is the measurement associated with the order receiving, put-away, replenishment, picking, and shipping activities. The goal for accuracy is 1 error per 1000 lines, but during the process more errors appears. According to studies, especially mixed pallets could have wrong items or wrong shelf-life or the wrong quantity roughly 30 % of the time. That's why identification of material (e.g. pallet) and its place is very important. If the material is improperly identified, it most likely to be delivered to wrong place, the inventory to be become incorrect and labour may have been wasted.

The main benefit of that – all movements of single pallet during a specific time period can be identified in the warehouse.

Fontanella (2004) suggests that there is a continuum of applications that range from using RFID for a specific application to different applications (Fontanella 2004). In addition, the configuration of WMS may play a critical role in attaining different applications. Usually managers are applying the technology across the warehouse. In addition, when RFID technology crosses the boundary of one application and is "attached" to another, then the equation becomes more complex (Spekman et al. 2006).

The most of RFID solutions involve infrastructure installations, which covers reading antennas and related equipment, network and communication systems (Holmqvist et al. 2006). That architecture is illustrated in Figure 2.1.

The figure 2.1 shows what is needed when enterprise is moving from paper-based process to RFID-based process. From Figure 2.1 we can see such actions, which have to be done in advance before RFID can be used:

- The implementation of reliable infrastructure,
- The preparation of warehouse management system,
- Preparation to collect large amount data,
- The equipment of sensors at forklifts,
- The placing tags on pallets and places (in front of doors or other locations).

The identification of forklift will help to find its place. Later, this can be used

for the construction of least-costs forklift routes.

The identification of pallets and place will help to save the time required for searching them manually.

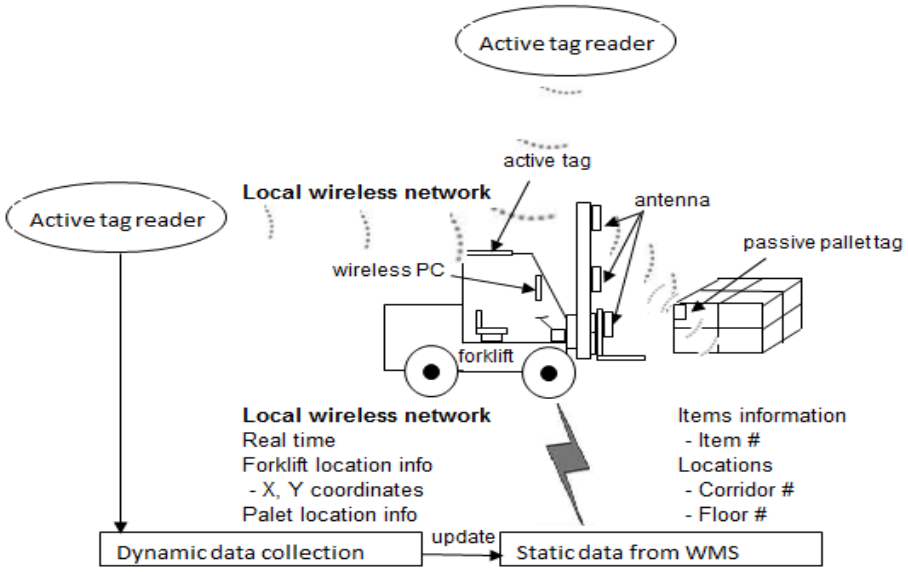

Figure 2.1. System architecture (Harry et al. 2007)

In addition, the infrastructure is the most important for RFID to work properly.

4. Operations in warehouse

The most important machine in warehouse is forklift. Basically, forklift is used for moving pallets inside warehouse. Forklift is used to move pallets from receiving to shipping area, from wide-aisle to narrow-aisle warehouse, etc. Forklifts are used in environments and applications that require different performance characteristics than other equipments. Forklift operations require a discrete signal that will ensure only that the desired pallet or location is identified. In addition, terminal is used to send messages (SME's) for the driver. The monitor on the forklift displays the message text. This is just one example of the specific performance requirements, which also gives the answer to the question, why organizations need this. Each organization should have wireless devices which have modules (and related antennas) to support RFID.

Antenna is a key component for forklift. Reading range is not one of the most important and valuable performance attributes for forklift operations. More

important is the ability to control the reading zone so you can read what you want and when you want it only. This may dictate different antenna depending on the object to be identified and its usage case.

The placement of antenna is also an important consideration. To prevent misreadings, antenna should be located as close to the target as possible. On forklifts, this means mounting antenna on the load rest. Because the cable between the antenna and the reader carries an analogue signal, the reader must also be located on the load rest to ensure minimum signal loss (Spekman et al. 2006).

So, this means, that RFID implementation is costly. But in other words, RFID implementations give higher control and higher return on investments.

In addition, the control of pallet movement within facility is as critical for accuracy as the control of receipts and shipments. The movement of a pallet from point A to point B is not critical itself, but if the wrong pallet is moved or if the right pallet is put in the wrong place, an error will occur. All internal material movements consist of two parts: a pick-up and a drop-off. The driver of forklift makes mistakes and when mistakes are made and they are not caught and corrected, suffers process quality. Warehouse elaborate schemes are often implemented for maximize productivity, but not accuracy. For the sake of both accuracy and productivity RFID can be used. By identifying location, driver reports where from the product taken and where placed. During the process, driver knows where to go, how much to pick and where to place it. Also RFID helps to minimise the costs of other operations, like manual picking, shipping, stock counting. Also the construction of least-costs forklift routes can help to increase productivity.

Practically, new tasks can be given and the most efficient route can be mapped out for the driver of forklift. In such case the forklift has to communicate with warehouse management system (WMS) on-line.

The author of this research find out, that Hassan (2010) functional block diagram can be applied seeking to show described main operations (see Figure 3.1).

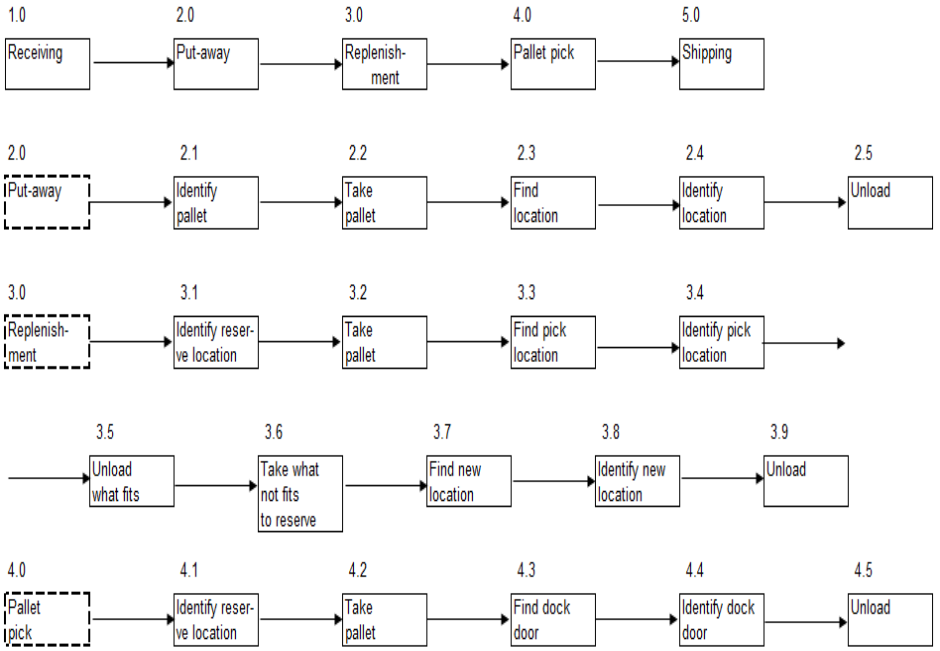

Figure 3.1. Operations in warehouse, which include the usage of RFID

The block presented bellow display how RFID is used in put-away, replenishment and pallet pick operations (see 2.1, 2.4, 3.1, 3.4, 3.8, 4.1, 4.4 blocks in Figure 3.1).

5. Experiment study

The objective of experimental study is to calculate how the identification of forklift will help for the construction of least-costs forklift routes; how identification of pallets and places will help to save time required for searching them manually; and what will be the effect related to minimisation of costs.

The first part of experimental study is dedicated for the identification of forklift and construction of least-costs forklift routes. The second part of experimental study is dedicated for the effect related to minimisation of costs identification and the last part of experimental study is dedicated to the identification of pallets and places and the time savings calculation.

For the first part of experimental study the Interactive warehouse simulation model is used.

The Interactive Erasmus Logistica Warehouse Website model offers opportunities to discover more ways to perform tasks (Oudijk et al. 2002) in the Microsoft Internet Explorer environment. There are different possibilities to compare different scenarios which depend from the number of aisles and cross-

aisles, length of aisles, position of computer station in warehouse. The only limitation of the model is that the maximum number of locations per aisle is limited to 68.

The Interactive warehouse simulation model will be used for optimising the way of forklift that is done between two transaction points.

Each time forklift gets a task, an event (or task) row is recorded in the information system. An event row can include the starting and ending time of task, thus enabling its duration to be calculated. Each consecutive pair of transaction points represents costs of activity (Varila et al. 2007).

The forklift driver starts route at computer station (Oudijk et al. 2002), goes to the front of the particular aisle; drives inside aisle, takes pallet, delivers it to pick location at the same or other aisle in shortest way, and, finally, returns back to the computer station. For calculation of forklift travel distance the optimal route was used mainly (can find in Figure 3).

This simulation model was used to perform replenishment tests, when:

- Reserve and pick locations were in different aisles (the first picture in Figure 3.2);
- Reserve and pick locations were in the front of aisle;
- Reserve and pick locations were in the end of aisle;
- Different number of corridors is used in warehouse (the third picture in Figure 3.2);
- The above mentioned is combined (the second picture in Figure 3.2).

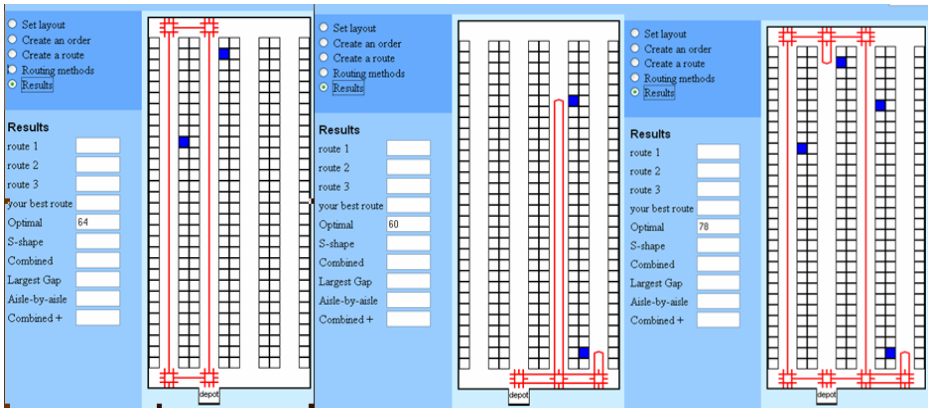

Figure 3.2. Interactive warehouse simulation model and different tests. Source: Oudijk et al. 2002

By running simulation tests with interactive warehouse simulation model it was seen that the best travel distance is when RFID is fully implemented. This means that the tasks are distributed to forklifts via SME's and forklift drivers

don't need to go to computer station. In such case, the way decreases by 27-37 % when driving without computer station is implemented and tasks are distributed to forklift drivers on-line.

Talking about costs, these results present the cases with and without RFID. As there are several choices for warehouses – paper or RFID.

In addition, Gray et al. (1992) propose to analyse savings in accordance with the components of warehouse operations. The main components of warehouse operations are such: travelling, grabbing, placing, closing (Gray et al. 1992):

- 'Travelling' associated with distance travelled by forklift,
- 'Grabbing' associated with the number of stops and finding right pallet,
- 'Placing' associated with the number of stops and placing the pallet to right place,
- 'Closing' associated with operations at the computer station (to confirm completed or uncompleted task, stock at location (if location is empty), and receive new task).

After each above mentioned component is studied:

- 'Travelling' component. Gagliardi et al. (2008) propose to calculate 1,5 minutes per performed task. On average during a day he spends an hour and a half for travelling in order to take a pallet and to place a pallet into new location. Comparing results of paper-based process and RFID-based process it is seen that the total travel distance of forklift can be reduced by 27-37 % under assumption that forklift is travelling with the same speed;
- 'Grabbing' component. Gagliardi et al. (2008) propose to calculate 1 minute per pallet taken from the old place (0.5 minute of this is needed for finding the right pallet and scanning location). If on average the driver of forklift picks 60 tasks, this means that during a day he spends around an hour to grab pallets;
- 'Placing' component. Gagliardi et al. (2008) propose to calculate 1.5 minute per pallet placed to new place. On average during a day the driver of forklift spends one hour and a half to place pallets;
- 'Closing' component. In paper-based process it takes some forklift driver's efforts to handle the job at the computer station. Gray et al. (1992) propose to calculate 0.5 minutes per task (Gray et al. 1992). If on average the driver of forklift picks 60 tasks, this means that during a day he spends around half an hour at the computer station.

According Gray et al. (1992), which propose to calculate daily forklift driver's costs, during half-day one driver, which is placed in forklift, costs 40

Euro, then 15 Euro costs travelling, 10 Euro – grabbing, 15 Euro – for placing pallet, 5 Euro - operations at the computer station (Gray et al. 1992). After comparison of paper-based process and RFID-based process some results occurred that show the benefits of RFID implementation are as follows: 37 % (5.55 Euro) of travelling costs and all closing costs (5 Euro costs related to job at the computer station) can be saved. Also half costs for grabbing pallets (5 Euro) can be saved, as RFID helps to avoid time needed for scanning pallets and locations – now forklift can identify them automatically; totally can be saved 15.55 Euro, i.e. around 38.8 % of driver costs.

The presented results show that forklift driver's costs can be reduced by around 38.8 %.

The savings in costs for 19 forklift drivers are 79.97 thousand Euro a year.

It is important to mention, that grabbing component is the main component in all other warehouse operations: receiving, put-away, full-pallet picking, and shipping activity, and the time needed for grabbing can be saved due to identification of pallets and places. If the savings only for grabbing component will be generated, the forklift driver's costs can be reduced by 12.5 %. This means that one third from total savings, which are 38.8 %, can be generated.

In addition, it should be mentioned that there are costs of terminal costs (5000 Euro) and the costs of forklift (which costs at least 20000 Euro). This means that if terminal and forklift will be included in such calculation, the reduction of travel distance would be shown in totally all costs and savings would be seen as much higher.

6. Conclusions

The study results show that the implementation of RFID is a priority in warehouses. By implementing RFID managers can have significant savings of warehouse costs, especially for forklifts, which are the most expensive machines used for manual operations in warehouses.

The usage of RFID can be linked with different operation in warehouses. In the paper various possibilities to use RFID in warehouse operations are analysed. It is shown how the costs can be reduced in operations. RFID helps to minimise the costs of many warehouse operations. In addition, when enterprise is moving from paper-based process to RFID-based process, many changes have to be taken in warehouses, such as:

- The implementation of reliable infrastructure,
- The preparation of warehouse management system,
- Preparation to collect large amount data,

- The equipment of sensors at forklifts,
- The placing tags on pallets and places (in front of doors or other locations).

When mentioned changes are in places, RFID can be implemented and savings can be generated. In the paper author calculated what effect can be reached with RFID implementation, which means the identification of forklift, pallets and places. To answer this question, author calculated how the identification of forklift will help for the construction of least-costs forklift routes; how identification of pallets and places will help to save time required for searching them manually; and what will be the effect related to minimisation of costs.

For some tests Interactive warehouse simulation model was used. The experiments demonstrate significant reduction of costs. It was calculated that travel distance can be reduced by 27-37 % due construction of least-cost forklift routes. In addition, the costs of forklift driver can be reduced by around 38.8 % due to construction of least-cost forklift routes and the reduction of time required for searching pallets and places manually. One third of this (12.5%) can be reduced only due to automatic searching of pallets and places.

References

A. Burinskiene, 'Information and telecommunication technologies usage for electronic business development', In proceedings of the 9th International Conference of Innovation and Logistics, Tel Aviv, pp. 1-8, 2008.

M. Ollivier, 'RFID Enhances Materials Handling', Sensor Review, Vol. 15, No. 1, pp. 36-39, 1995.

M. Holmqvist, G. Stefansson, 'Mobile RFID: a case from Volvo on innovation in SCM', In proceedings of the 39th Hawaii international conference on system sciences, pp. 1-10, 2006.

E. M. Rogers, 'Diffusion of innovations', New York: Free Press, p.165, 2003.

Eurostat, Database [on-line], retrieved on 2 August 2008, available from the Internet: http://epp.eurostat.ec.europa.eu, 2006.

M. Varila, M. Seppanen, P. Suomala, 'Detailed cost modelling: a case study in warehouse logistics', International Journal of Physical Distribution & Logistics Management, Vol. 37, No. 3, pp. 184-200, 2007.

S. C. Ailawadi; R. Singh, 'Logistics Management', PHI Learning Ltd, 2005.

W. Lorchirachoonkul, P. T. M. John, 'RFID implementation with virtual infrastructures', Business Process Management Journal, Vol. 16 No. 6, pp. 917-931, 2010.

Ubiquiti Networks official site, 2017, [online], available from Internet: http://www.ubnt.com.

Communications Regulatory Authority of Lithuania, 2017, official site [online], available from Internet: http://www.rrt.lt.

J. P. T. Mo, Q. S. Sheng, X. Li, S. Zeadally, 'RFID infrastructure design: a case study of two Australian national RFID projects', IEEE Internet Computing Vol. 13, No. 1, pp. 14-21, 2009.

R. E. Spekman, P. J. Sweeney, 'RFID: from concept to implementation', International Journal of Physical Distribution & Logistics Management, Vol. 36, No. 10, pp. 736-754, 2006.

S. Kumar, E. Swanson, T. Tran, 'RFID in the healthcare supply chain: usage and application', International Journal of Health Care Quality Assurance, Vol. 22, No. 1, pp. 67-81, 2009.

A. Anonymous, 'Technology by OMRON to produce RFID tags', OMRON Corporation, Wakahiro, Kawai, 2005.

A. G. Kok, K. H. Donselaar, T. Woensel, 'A break-even analysis of RFID technology for inventory sensitive to shrinkage', International Journal of Production Economics, No. 35, pp. 11-18, 2008.

J. Fontanella, 'Finding the ROI in RFID', Supply Chain Management Review, Vol. 8, No. 1, pp. 13-24, 2004.

K. H. Harry, K. L. Chow, W.B. Choy, L. Chan, F. T.S. Chan, 'Integration of web-based and RFID technology in visualizing logistics operations', Supply Chain Management: An International Journal, Vol. 12, No. 3, pp. 221-234, 2007.

LXE (An EMS technologies company), Information on-line, retrieved on 24 October 2010, available from the Internet: http://www.lxe.com, 2006.

M. M. D. Hassan, 'A framework for selection of material handling equipment in manufacturing and logistics facilities', Journal of Manufacturing Technology Management, Vol. 21, No. 2, pp. 246-268, 2010.

D. Oudijk, K. J. Roodbergen, R. De Koster, M. Mekern, 'Shelf Area Warehouse Simulation', Interactive Erasmus Logistics Warehouse [online], Erasmus University Rotterdam and Stichting Logistica, retrieved on 24 November 2010, available from the Internet: http://www.roodbergen.com/warehouse, 2002.

A. E. Gray, U. S. Karmarkar, A. Seidmann, 'Design and operation of an order-consolidation warehouse: models and application', European Journal of Operational Research, No. 58, pp. 14-36, 1992.

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