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ORDER PICKING SYSTEM EVALUATION USING RTLS METHOD

BENCE PALLAI[1] - PÉTER TAMÁS[2] - HENRIETT MATYI[3]

Abstract: In order to maintain competitiveness, it is essential for modern industrial companies to record as much data as possible, by processing which they can obtain valuable information for the development and optimization of production and logistics processes. The RTLS system provides an opportunity to perform this task. RTLS, or Real Time Location System, is a Real-Time Local Positioning System used to identify people and moving objects and to determine and continuously track their current position in a configurable space. Real-time positioning can help us to locate the position of objects and people inside the building. The paper presents and compares the relevant RTLS systems used in practice. In addition, the implementation process of an RTLS system created at the Institute of Logistics is described, as well as its application potential in relation to a case study developed. The abstract contains a short, general description of the topic and the research shown in the paper.

Keywords: *RTLS, logistics, location definition*

1. INTRODUCTION

To remain competitive, it is essential for modern industrial companies to capture as much data as possible, which can be processed to obtain valuable information for the improvement and optimization of production and logistics processes. This data can include, for example, the exact location, movement and possible utilization of forklift trucks, vehicles, human resources, and products. With the required data, we can create faster product manufacturing and/or lower space requirement storage systems implement more efficient route planning, and/or uncover unused resources. For solving these tasks, most people immediately think of using various GPS technologies that are widely available and accessible to almost everyone, which are fine outdoors, but they do not provide an ideal solution within four walls. Different RTLS systems have been developed to overcome this obstacle [1]. But what is RTLS, or real-time location system? The name Real Time Location System (RTLS) stands for Real Time Location Positioning System, which is used to identify persons, moving objects and to determine and continuously track their position in a defined space. Real-time localization can help to locate the position of objects and people within a building [4]. The paper introduces the basic concepts related to localization and the process of implementation and use of an RTLS system installed at the Institute of Logistics of the University of Miskolc through a case study.

2. BASIC DEFINITIONS RELATED TO LOCATION TRACKING

Several basic concepts related to location have been defined and are described below:

[1]logistics engineer Bsc student., University of Miskolc, Institute of Logistics, Hungary
bence.pallai@gmail.com
[2]university professor, director of the institute, University of Miskolc, Institute of Logistics, Hungary
peter.tamas@uni-miskolc.hu
[3]PhD student, University of Miskolc, Institute of Logistics, Hungary
henriett.matyi@uni-miskolc.hu

- Reference points [2]: The basic elements of positioning are called reference points. The reference point can be a star of other celestial body, but in this case, the reference point is an "immovable" point located in a warehouse or hall. In a warehouse, these are usually support walls, cross beams, which are "immovable". The common characteristic of all reference points is therefore immobility, immovability – a permanent stable geological position [3].
- Anchors [2]: A rope or chain of a certain length is anchored to the reference points. In the plane a circle of a given length (radius) can then be "drawn" around a point, while in space, a spherical surface of a given length can be "drawn" around the reference point with the end of the rope. The resulting shape gives the set of possible points corresponding to a given distance from the reference point, which is called an anchor in positioning. Three sensors can be used to determine the current position of any point in a two-dimensional coordinate system, in which we can find our exact position. However, for three-dimensional positioning you need at least 4 anchors.
- Transponders (tags) [2]: The RTLS transponder is the usually small electronic unit whose position in the logistics system is to be determined.
- Trilateration [2]: The most commonly used positioning method uses geometric bases for positioning. The most common method can be measured, then we know that we are in a circle of the correct radius around the anchor (in the plane). If we measure the distance with three anchors (on a plane), we can see that our position is clearly determined by the intersection of three circles. This method is called trilateration (or "multilaterion" if you use more than 3 anchors).

3. DESCRIPTION OF LOCATION TECHNOLOGIES

This chapter summarizes the most often used technologies in the field of positioning:

- UWB technology [2]: UWB ultra-wideband signals have a bandwidth of at least 500 MHz. This temporal resolution is so fine that at the customer (reference point) we can distinguish the original (measured) signal (pulse) from other reflections at the receiver (reference point). The technology that promises the highest accuracy of all (approximately 10 centimeters, depending on the number of antennas placed), within an effective range of about 50 meters. It is also the most flexible technology in terms of system evolution.
- WIFI technology [2]: WIFI technology in general is already available in many modern warehouses, with a radio network using the appropriate central frequency, which is used by mobile devices involved in logistics processes. So, the question is, if the network is already available, why not use it for distance measurement? Well, this technology does not offer sufficient accuracy even in the optimal case, but any object in the vicinity of the receiver (walls, racking, forklift trucks) will create additional reflections of the signal which will be detected by the receiver and generate even more inaccurate results. However, it also offers a relatively cheap alternative for companies for whom a high degree of inaccuracy (up to 2-3 meters) is not a problem.
- BLE – RSSI (Bluetooth Low Energy – Received Signal Strength Indication) technology [2]: The measurement is based on the principle that the further apart the two points are, the lower signal strength between them at the receiving end. From this RSS (i.e., received signal strength) value, their distance can be inferred.

Unfortunately, for a Bluetooth (2.4 GHz) radio, the received signal strength will also be a combination of the result of all reflections, not just a "clean" pulse for the distance to be measured.

- Less common RTLS technologies: There are also RTLS technologies that are much less commonly explored in industry. Their existence is nevertheless justified and, due to their low deployment and possible maintenance cost, they may be a suitable alternative for smaller factories. However, in larger plants, the deployment and use of such technologies would require a lot of trade-offs, which in most cases would be completely against the aspirations of the times. Examples include significant inaccuracy, leaving a large sensor environment free, frequent sensor placement, or the need for visual contact. Less common technologies include Zigbee, infrared, laser, and passive systems.

4. COMPARISON OF RTLS TECHNOLOGIES PREFERRED IN INDUSTRIAL ENVIRONMENTS

Comparing different technologies and choosing the most appropriate one for the task is not simple. As each company is unique, different aspects may come to the forefront or recede into the background. Table I compares the most used technologies according to the most important criteria.

Table I.

Comparing technologies [1-4]

Technology	***UWB technology***	***WIFI technology***	***BLE - RSSI***
Sensing distance	50 meters	50 meters	25 meters
Accuracy (ideally)	1-10 centimeters	1 meter	1-3 meters
Energy consumption	low	high	low
Cost of implementation	high	medium	low

Perhaps the most important aspect of the requirements of the modern era is accuracy, in which UWB technology stands out significantly from other technologies [4]. Furthermore, this technology is perhaps the least compromised choice, as its battery life can reach several years (depending on the distance measurement technology), and only the immediate surrounding of the signal transmitters needs to be left unobstructed, as large metal objects can block the signal. In areas where meter accuracy is sufficient, both WIFI and Bluetooth technology can be an excellent alternative. WIFI networks are already available in most places, but transmitters designed for this purpose are very expensive. In addition, a relatively large area around the transceivers must be left free to avoid signal reflection, which does not result in a very good use of space. Bluetooth technology may only be a good option for a relatively small number of users, but it is a very good option. The disadvantage of this technology is that it only gives "accurate" data in open areas, but even then, it is not close to the accuracy of UWB technology, and any object passing between the transmitter and the receiver can seriously affect the reading, providing erroneous information.

5. POSSIBLE APPLICATIONS OF THE RTLS SYSTEM IN LOGISTICS

This chapter summarizes the practical applications of the RTLS system, which are:

- Application of the system in education: Learning about the system provides students with a significant professional development opportunity, as it is a technology that can be the basis for modern logistics systems.
- Demonstration of the application of lean methods: The possibilities to compare the initial processes are increased by using the RTLS system, so the effectiveness of the application of lean tools can be better demonstrated.
- Accident prevention: In some lab cases, the student may accidentally get lost in the wrong place. In such cases, a safety system based on RTLS can be important. We place tags on mobile equipment (automated loading machines, self-driving forklift) and ask students to wear one themselves. When the two tags get too close to each other, the system detects this and stops immediately.
- Warehouse management: Perhaps one of the most obvious examples for everyone, after learning about the technology in more detail, is its use in warehouse management and possibly records. We put tags on parts, semi-finished or fully finished products, and if we need it, we will know exactly where it should be, even in the faulty storage. In some factories, even when a product leaves the detection zone, or a certain part of it, the system automatically takes care of the paperwork.
- Transit time analysis: A product equipped with an RTLS transmitter can be tracked throughout the entire production process, while the system records its exact location and the exact time it was there. This can be very helpful, for example, in determining bottlenecks, but can also be used to compare multiple production lines.
- Human resource traceability: We monitor the real-time location and movement of workers using the tags provided to workers, which are documented by the system. By using this, we can uncover potential unnecessary movements, even in certain systems where we can provide optimal routes for them and alleviate potentially overloaded routes.
- Observance of mandatory social distancing: In the current Covid-19 situation, and for instance in healthcare generally, it is advisable to maintain an appropriate distance to prevent the spread of the disease. The RTLS system may provide a suitable alternative for this purpose. Patients and visitors are equipped with a tag specially designed for this purpose, which trigger an audible signal if they approach each other too closely, thereby drawing attention to the need for mandatory social distancing.
- Theft protection: The most valuable equipment and objects in the unit are equipped with these tags. In the system, we designate which zones these products need to remain in. If they leave the designated area, the security personnel will be alerted, providing the last known position.

6. THE PROCESS OF IMPLEMENTING THE RTLS SYSTEM

The RTLS system in the Logistics 4.0 lab has been implemented according to the following process (Fig. 1):

1. Mapping the area: Before the RTLS system could be selected and ordered, it was necessary to survey the laboratory. To select the right technology, it was necessary

to know the size of the area, the possible ceiling height, and the materials present in the laboratory that could block or interfere with the waves of certain technologies.

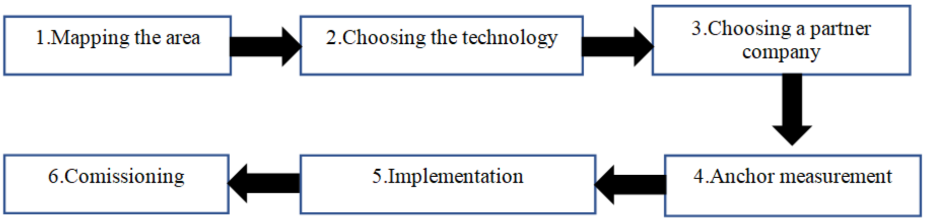

Figure 1. Description of RTLS implementation

2. Choosing the technology: The information obtained from the mapping was used to choose the technology. As the area and ceiling height of the laboratory are not considered large compared to the size of a factory for which these instruments are designed, the most important priority was accuracy. This characteristic makes the UWB stand out compared to other technologies, as up to ten times the accuracy can be achieved with the right installation.
3. Choosing a partner company: The RTLS system for the University of Miskolc, Institute of Logistics was provided by IBCS Hungary LLC. The company is interested in allowing future logistics engineers to learn about and test the technology themselves, which will help to realize the concept of the smart factory.
4. Anchor measurement: Knowing the technology to be installed and the desired localization accuracy, the next step is to select the location and type of transponders. The antennas should have the best possible view of each other. The antennas should also be at the same height. This has been determined in the institute's laboratory at 270 centimetres. At this height there are no signal blocking factors, so 4 transceivers can receive signals from all points in the laboratory.
5. Implementation: Once the types and locations of the anchors are known, the first phase of installation can begin, which involves the precise positioning of the anchors. Knowledge of the anchor type is important for determining the location of the Ethernet connector, which can greatly affect the layout of the area. Next, the central server is set up. Since the information and settings can be accessed through the web interface at any time, it is not necessary for the server to be in a central location, but it must be easily accessible in case of any issues. Additionally, it is important to ensure that the cables connected to the server do not cause any interference. After this, the received devices are mounted in the designated locations and connected to the network.
6. Commissioning and maintenance: The first step in commissioning is to add the laboratory map and specify its size and scale (Fig. 2). Next, the antennas are set up. The antennas installed in the laboratory have already been pre-configured with their IP addresses before arrival at the university. The IP address of the server that the antennas connect to must be set, which is done one-site. After this, the antennas can be found in the software. Once added, the program designates one of the antennas as the master, with the general recommendation being to set up at least two, preferably facing each other. In the laboratory, antennas one and three are masters. User

accounts are then created, with a new password assigned and the system administrator user with full privileges potentially renamed. A user account with limited privileges (only for viewing, not modification) for students is then created, with a password also assigned.

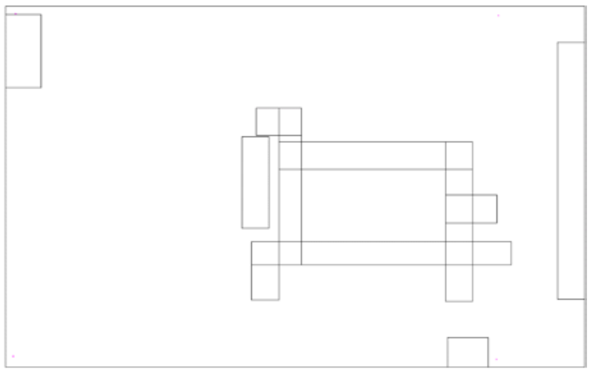

Figure 2. The map used in the lab software reviewed

7. TESTING THE COMMISSIONING PROCESS USING THE RTLS SYSTEM

In this chapter, we examine two ways of implementing a given picking plan using the RTLS system. Once the tests have been carried out, the appropriate picking strategy is selected.

Commissioning task to be fulfilled (objects are marked as shown in Fig. 3):

1. Unload 20 pieces of type “A” products from the rack marked with red color, then unload 20 type of “B” products from the rack marked with green color.
2. Unload 20 pieces of type “A” products from the rack marked with red color, then unload 20 type of “B” products from the rack marked with green color.
3. Unload 20 pieces of type “A” products from the rack marked with red color, then unload 20 type of “B” products from the rack marked with green color.

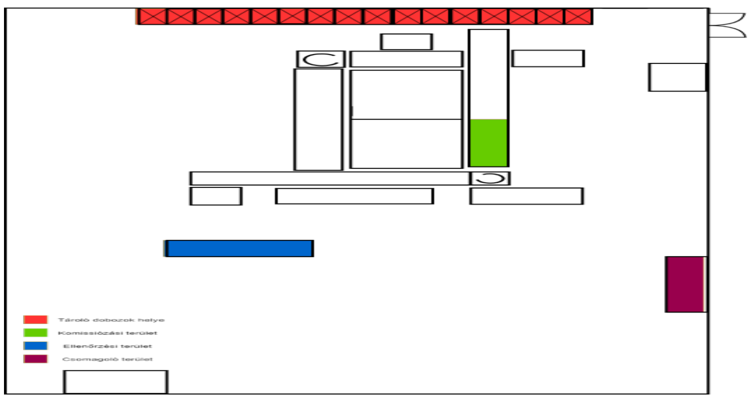

Figure 3. Measurement-related zones

The products of “A” and “B” belonging to one order are placed in one unit load.

Other information:

- The quantity of unit load stored in the rack system marked in red is 20 pieces.
- The quantity of unit load stored in the rack system marked in green is 20 pieces.
- The capacity of unit load used for commissioning is 40 pieces.

Commissioning strategies:

- One-step commissioning: During the first measurement, one-step commissioning takes place. With the help of the order form, the worker complies the commission according to the customer’s needs for each order.

Steps:

1. The storage boxes containing 20 pieces of product “A” are unload one by one (Fig. 4: 1,5, 9).
2. The storage boxes are transported to the commissioning point (Fig. 4, 1->2; 5->6; 9->10).
3. Unload 20 pieces type “B” from the commissioning point.
4. The order will be complied.
5. The complied order is transferred to the inspection area (Fig. 4., 2->3; 6->7; 10->11).
6. The order is checked (Fig. 4., 3,7,11)
7. If compliant, the package will be transferred to the packaging area (Fig. 4., 3->4; 7->8; 11-> 12).
8. The order is packed and then unloaded (Fig. 4. 4, 8, 12).

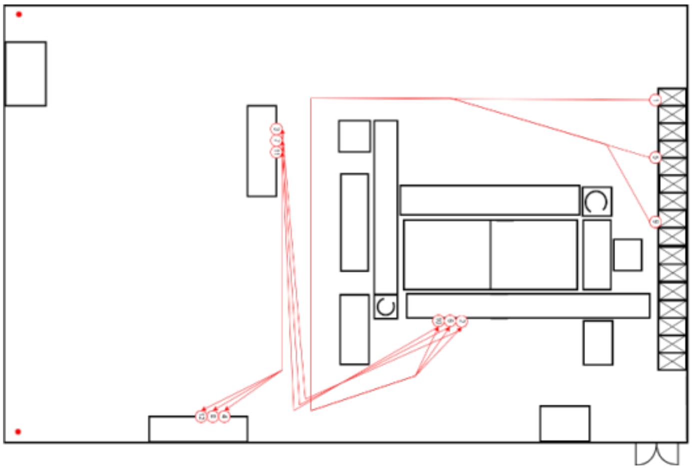

Figure 4. One-step commissioning

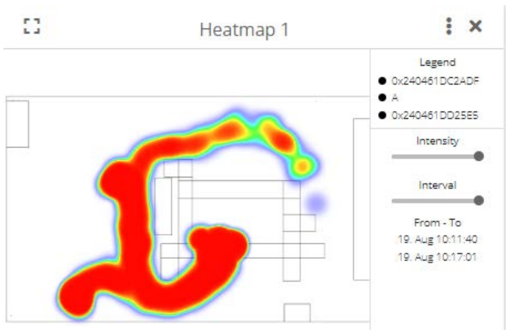

Figure 5. Heat map visualization of one-step commissioning

The time needed to complete the whole process: 5 minutes 21 seconds.

- Two-step commissioning: Here the worker picks orders in groups rather than individually, as in one-step picking.

Steps:

1. The 3 storage boxes, each containing 20 pieces of product "A", are unloaded, and then placed on a storage trolley for easier transport (Fig. 6. 1,2,3).
2. The storage boxes are transferred to the commissioning point (Fig. 6. 3->4).
3. 20 "B" products are removed from the commissioning point (Fig. 6. 4).
4. The order is assembled.
5. The picked orders are transferred to the inspection area at the same time (Figure 6., 4->5).
6. The orders are checked (Fig. 6. 7)
7. If compliant, the parcels are transferred to the packaging area at the same time (Fig. 6. 7->8).
8. The order is packed and then unloaded (Fig. 6. 8)

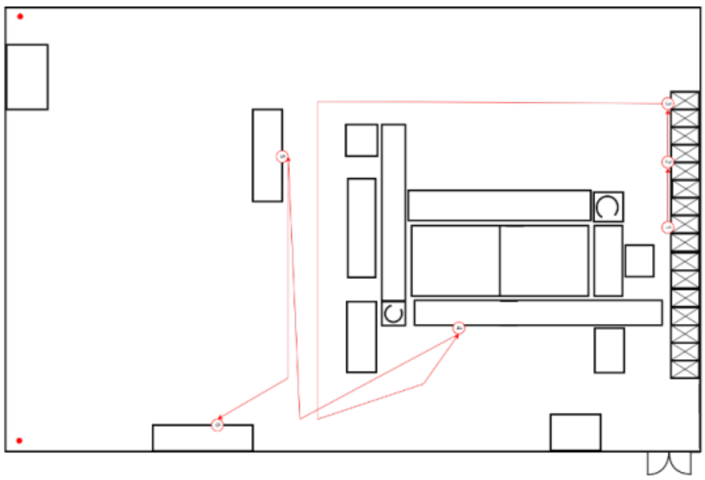

Figure 6. Two-step commissioning

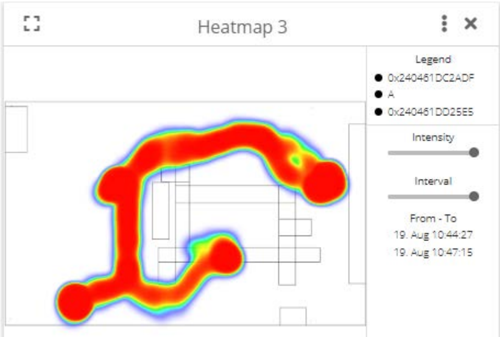

Figure 7. Heat map visualization of two-step commissioning

The time needed to complete the whole process: 2 minutes 58 seconds.

As a result of the study, it can be concluded that the two-step commissioning strategy is the most efficient in terms of the number of tasks to be performed.

8. SUMMARY

In this publication, the basic concepts and technologies related to positioning have been reviewed and the RTLS technologies preferred in industrial environments have been compared. Furthermore, the process of implementing an RTLS system installed in the Logistics 4.0 laboratory was presented and the efficiency of the one-step and two-step picking process was investigated through a case study. The publication was based on the Scientific Students' Associations thesis of Bence Pallai [5].

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