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Abstract: The aim of this post is to point out the use of RFID robots in the management of logistics processes. RFID technology is defined first. RFID technology represents identification using radio frequency waves. The principle is to store the necessary data in radio frequency memory chips and then repeatedly read or write the data using a reader. We divide RFID chips into active and passive. Active RFID chips use energy from a battery, while passive RFID chips are a technology without an internal power source. Passive RFID is the most common form of RFID in warehouses, using which inventory is taken using RFID robots or hand-held RFID readers. Nowadays, many RFID robots from different manufacturers are available on the market. When choosing, I must consider where we want to use the RFID robot and choose the one that suits us based on its specific characteristics. The RFID robot is a mobile and autonomous RFID system that performs an inventory of the given space based on our initial setup. The RFID robot locates each item in 2 dimensions (x and y). Most robots can move in all directions because they can rotate without shifting. The accuracy of the inventory using the RFID robot ranges from 95-99%, while the accuracy of the inventory performed by employees using handheld RFID readers ranges from 85-95%. As for speed, it is on average 10 times faster compared to manual RFID readers.

1 Introduction

We live in a world full of smart devices. We have smartphones, smart home appliances, smart sensors, and many others. We could write this list for a very long time and will probably continue to increase. It is thanks to the engineers who design equipment using information technology. New electromechanical components now they can quickly process and calculate large amounts of data. Products made using this technology can not only fulfil their original role but can also do much more. By interconnecting smart devices, the world has become more accessible. Smart devices are used almost everywhere, making the Internet of Things popular with businesses and services in all industries. One of these technologies is radio frequency identification (RFID).

We have divided this article into two parts. The first part is devoted to the definition of RFID technologies and the classification of RFID tags and their advantages and disadvantages. The second and main part is devoted to the use of RFID robots in the management of logistics systems. In this section, you will also get information on the advantages and disadvantages of using RFID robots, which are then explained in the conclusion.

1.1 Internet of Things (IoT)

The term "Internet of Things" (IoT) was first used in 1999 by British technology pioneer Kevin Ashton to denote a system in which objects in the physical world could connect to the Internet using sensors. Ashton coined the term to illustrate the power of attachment of radio frequency identification tags (RFID) used in corporate supply chains to the Internet to count and track goods without the need for human intervention [1].

The Internet of Things (IoT) is a global network infrastructure that connects physical and virtual objects using data collection and communication capabilities [2]. It will offer specific object identification, sensor, and connectivity options as a basis for the independent development of cooperative services and applications. They will be characterized by a high degree of autonomy in data capture, event transmission, network connectivity, and interoperability [3].

1.2 RFID technology

RFID is an abbreviation of the English word Radio Frequency Identification, so it is about radio-frequency identifiers working in the high-frequency band. As one of the main areas of possible use, during the introduction of RFID technology, use as an alternative to the barcode was

considered. Compared to the RFID barcode, the technology offers higher scanning speed and easier deployment in automated systems. RFID elements and systems are most often divided according to:

- Frequency band.
- Type of identification element.
- RFID application.

Radiofrequency identification (RFID) - is used for automatic object identification and capturing data about that object that is stored in a small microchip tag and attached to the object. The RFID tag has a built-in antenna that communicates with the sensor a device that reads the data remotely. The data is then transmitted from the sensing device to the enterprise application software in which they are stored. Each RFID tag has its own unique identification number [4].

RFID can be used to record and control the movement of assets and employees. Tags You've probably seen RFID on the back of library books or even new books biometric passports [5].

1.3 Passive RFID

A technology without an internal power source that uses radio to send the signal waves created by the RFID reader. Passive RFID is the most common form of RFID in warehouses. In Table 1 we can see the advantages and disadvantages of passive RFID [6].

Table 1 Advantages and disadvantages of passive RFID

Advantages	Disadvantages
Low cost (~ €0.10 per label)	Expensive RFID signal readers are required
Small dimensions and weight	There is a short-range
Use up to 20 years	Unable to save memory

1.4 Active RFID

Technology that uses battery power to continuously broadcast a unique identifier label into the given reader. Active RFID is not as common in warehouses as passive RFID. In Table 2 we can see the advantages and disadvantages of active RFID [7].

Table 2 Advantages and disadvantages of active RFID

Advantages	Disadvantages
Long reading range	Higher costs (~ €20 per label)
Readers with lower performance	Battery life 3-5 years
They can have both sensors and data storage	Larger size and weight

2 Types of RFID systems

There are three main types of RFID systems: low frequency (LF), high frequency (HF), and ultra-high frequencies (UHF). Microwave RFID is also available. Frequencies vary widely depending on the country and region [7].

- Low-frequency RFID systems. These range from 30 kHz to 500 kHz, though typically the frequency is 125 kHz. LF RFID has short transmission ranges, in general from a few centimetres to approximately 1 meter.
- High-frequency RFID system. These range from 3 MHz to 30 MHz, while the typical HF frequency is 13.56 MHz the standard range is less than 2 meters.
- UHF RFID systems. These range from 300 MHz to 960 MHz, with a typical with a frequency of 433 MHz and can generally be read from more than 7.5 meters.
- Microwave RFID systems. These run at 2.45 GHz and can be read at more than 9 meters.

2.1 Advantages of RFID technology in logistics

One of the most significant advantages of this technology is the possibility to assign a unique number for a specific assortment of items, which can be useful if your warehouse receives and stores goods from several suppliers at the same time [8].

In addition to a more accurate view of inventory status, RFID technology allows you to track average delivery times and track inventory in and out in real-time, which will help ensure the correct shipment of the item and reduce the number of product returns [10].

2.2 RFID robot

The fields of artificial intelligence, automation, and robotics scored in the last decades of tremendous growth and innovation. RFID inventory accuracy with handheld RFID readers could exceed 98%, but flawed procedures and human error reduce this accuracy to 85 - 95%. The RFID robot is a mobile and autonomous RFID system that automatically performs the inventory of a given space, for example, a retail store or a warehouse, which provides higher RFID inventory accuracy than handheld readers. Inventory accuracy ranges from 95 - 99%. It works completely autonomously: the user specifies when the inventory should be performed, and the bot starts when it is scheduled. RFID the robot also locates each marked item in 2 dimensions (x and y) [12]. This information is given to process to create a planogram of items inside the space. Information-generated RFID robots can be used to help employees detect wrongdoing placed items, to speed up the management of picking and returning goods, and for purposes of money mapping and other operational processes [13]. Most RFID robots can already move in all directions because they can rotate without shifting. Therefore, it can easily move around any space. Speed is synchronized with tag reading to maximize reading speed. The RFID robot contains: - an RFID system with a certain

number of antennas, which depends on the size of the given RFID robot. Currently, there are several companies (see Table 3) that are dedicated to the production and provision of RFID robots.

Table 3 Producer and brand of RFID robot

Producer	Brand of RFID robot
keonn	Robin-200™
MetraLabs	TORY RFID
PAL Robotics	StockBot
fetch robotics	TagSurveyor
Simbe Robotics	Tally RFID

In Figure 1, we can see RFID robots from PAL Robotics, Simbe Robotics, and fetch robotics.

Figure 1 RFID robots

Each of the listed RFID robots (see Table 3) has specific properties that distinguish it from others. The biggest difference is how high it can scan RFID tags. Among others, the differences include autonomous navigation and obstacle avoidance, the possibility of autonomous docking and charging, the possibility to plan to scan routes, uploading data to the server customer in various formats, and many others [14].

Most RFID robots work on the same principle. We can summarize these principles in four points [16,17].

1. During the first operation in a new space, the RFID robot mostly moves around the space using the interface application. In this step, the RFID subsystem does not work.
2. This user-guided navigation allows you to automatically generate a map space. This mapping process needs to be repeated only if will significantly change the layout of the space.
3. The user plans when the RFID robot should perform inventories. For example, every day at 22:00. At the indicated time, the robot will begin to move autonomously around the space, reading and locating RFID tags and storing this information.
4. After it completes its inventory, it navigates back to its docking station to recharge.

2.3 Use of RFID robot in logistics

Poor inventory management is one of the distribution's biggest nightmares because it has a negative impact and means losses for the company due to incorrect data on stock and errors during transportation [19]. Using RFID robots allows us to get an overview of where items are located and how much stock is available to avoid pre-stocking and insufficient supply due to possible product losses. The use of RFID robots helps reduce the number of human errors that can have a significant impact on warehouse management. That also helps free up employees to work on higher-value tasks, such as optimizing warehouse management and providing better customer service.

The use of RFID robots in logistics brings many advantages, but also disadvantages, which are shown in Table 4.

Table 4 Advantages and disadvantages of using RFID robot

Advantages	Disadvantages
High accuracy	High entry costs
High speed	Interference
Multiple scanning	Data protection issues
Many formats	
Cost reduction	

It is clear from the table that the use of RFID robots brings us more advantages than disadvantages. The RFID robot can recognize and capture 98% of all products marked with an RFID label. As for speed, it is on average 10 times faster compared to manual addition supplies. It can also scan many more items at once compared to handheld RFID scanners. All scanned data is stored and sent to corporate information systems companies. The data is stored in various formats so that we can use it further. Since The RFID robot works autonomously, thus we can reduce labour costs.

A big disadvantage when implementing RFID technology and buying an RFID robot is that they are expensive entry costs, which will be returned to us over time. Another of disadvantage of using RFID in the robot may be the inaccuracy of the scanned data because certain materials such as heavy metals and radio wave sources can interfere with data transmission. The use of RFID technology and RFID robots can pose a data protection risk. These data will prove to us to be hacked by hackers. For this reason, it is very important to have well-secured data and invest in security software [20].

3 Conclusions

The main contribution of the article is defining the advantages and disadvantages of using RFID robots in the management of logistics processes. Currently, there are

many companies dedicated to the production of RFID robots. Among the most famous companies that are engaged in the production of RFID robots are MetraLabs, PAL Robotics, Simbe Robodics and many others. Each one of the manufacturers specifies a certain type of RFID robot, according to its use. We can use them in retail operations, but also in large logistics warehouses. Each RFID robot has its own specific characteristics that distinguish it from the others. The main differences include the size of the RFID robot itself, the number of RFID antennas, the speed of movement, the speed of scanning RFID tags, the accuracy of scanning RFID tags, autonomous navigation and obstacle avoidance, the possibility of planning routes and several data storage formats.

The RFID robot is a mobile and autonomous RFID system that performs an inventory of the given space based on our initial setting, which we can adjust according to needs. During the inventory, the RFID robot locates each item in 2 dimensions (x and y), while all the information is stored and then we can use it for further processing. The accuracy of the inventory using the RFID robot ranges from 95-99%, while when inventorying by employees using manual RFID readers it ranges from 85-95%. This accuracy is lower mainly due to human errors or the use of faulty procedures. Another great advantage of using an RFID robot is the speed of scanning RFID tags, but also the speed of taking inventory. As for the scanning speed of RFID tags, it is 10 times faster compared to manual RFID scanners. Other benefits include multiple scanning, saving data in different formats, and cost reduction despite high input costs is very important.

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References

[1] GREGOR, T., MAGVAŠI, V., GREGOR, M.: Internet vecí (IoT), *Productivity and Innovation*, Vol. 16, No. 2, pp. 35-41, 2015. (Original in Slovak)
[2] BURGANOVA, N., GRZNÁR, P., MOZOL, Š.: *Challenges of factory of future in the context of adaptive manufacturing*, Conference: Invention for enterprise, InvEnt 2021, Zilina, 2021.
[3] STRAKA, M., SPIRKOVA, D., FILLA, M.: Improved efficiency of manufacturing logistics by using computer simulation, *International Journal of Simulation Modelling*, Vol. 20, No. 3, pp. 501-512, 2021. https://doi.org/10.2507/IJSIMM20-3-567
[4] FEDORKO, G., VASIL, M., BARTOSOVA, M.: Use of simulation model for measurement of MilkRun system performance, *Open Engineering*, Vol. 9, No. 1, pp. 600-605, 2019. https://doi.org/10.1515/eng-2019-0067
[5] KOVALČÍK, J., BALOG, M.: Automatic identification systems for management - material flow control and stock status, *Acta logistica*, Vol. 8, No. 1, pp. 55-64, 2021. https://doi.org/10.22306/al.v8i1.202
[6] ZUPANCIC, D., BUCHMEISTER, B., ALJAZ, T.: Reducing the Time of Task Execution with Existing Resources – Comparison of Approaches, *International Journal of Simulation Modelling*, Vol. 16, No. 3, pp. 484-496, 2017. https://doi.org/10.2507/IJSIMM16(3)10.394
[7] DURICA, L., GREGOR, M., VAVRIK, V., MARSCHALL, M., GRZNAR, P., MOZOL, S.: A Route Planner Using a Delegate Multi-Agent System for a Modular Manufacturing Line: Proof of Concept, Applied Sciences, Vol. 9, No. 21, pp. 1-20, 2019. https://doi.org/10.3390/app9214515
[8] HRICOVA, R., BALOG, M.: Introduction of RFID System into Transport and Defining its Model of Return on Investment, *International journal of engineering research in Africa*, Vol. 18, pp. 130-135, 2015. https://doi.org/10.4028/www.scientific.net/jera.18.130
[9] MORAVEC, M., BADIDA, M., MIKUSOVA, N., SOBOTOVA, L., SVAJLENKA, J., DZURO, T.: Proposed Options for Noise Reduction from a Wastewater Treatment Plant: Case Study, *Sustainability*, Vol. 13, No. 4, pp. 1-22, 2021. https://doi.org/10.3390/su13042409
[10] MARASOVA, D., SADEROVA, J., AMBRISKO, L.: Simulation of the Use of the Material Handling Equipment in the Operation Process, *Open Engineering*, Vol. 10, No. 1, pp. 216-223, 2020.
[11] MARSCHALL, M., GREGOR, M., DURICA, L., VAVRIK, V., BIELIK, T., GRZNAR, P., MOZOL, S.: Defining the Number of Mobile Robotic Systems Needed for Reconfiguration of Modular Manufacturing Systems via Simulation, *Machines*, Vol. 10, No. 5, pp. 1-20, 2022. https://doi.org/10.3390/machines10050316
[12] LENORT, R., FELIKS, J., TVRDON, L.: production *Logistics concepts and systems in metallurgical companies*, 22nd International Conference on Metallurgy and Materials, METAL 2013, pp. 1867-1872, 2013.
[13] MOZOLOVÁ, L., GRZNÁR, P., MOZOL, Š., FURMANNOVÁ, B.: *Development of digital*

support tools, Conference: Invention for Enterprise, InvEnt 2021, Zilina, 2021.

[14] LOUCANOVA, E., OLSIAKOVA, M., DZIAN, M.: *Open innovation system in business process in the global market*, 17th International Scientific Conference on Globalization and Its Socio-Economic Consequences, pp. 1347-1353, 2017.

[15] CHROMJAKOVA, F., BOBAK, R., HRUSECKA, D.: *Production process stability – core assumption of Industry 4.0 concept*, 5th International Conference on Manufacturing, Optimization, Industrial and Material Engineering, pp. 143-154, 2017.

[16] GABAJOVÁ, G., KRAJČOVIČ, M., MATYS, M., FURMANNOVÁ, B., BURGANOVÁ, N.: Designing virtual workplace using unity 3D game engine, *Acta Tecnología*, Vol. 7, No. 1, pp. 35-39, 2021. https://doi.org/10.22306/atec.v7i1.101

[17] GLOVA, J., SABOL, T., VAJDA, V.: Business Models for the Internet of Things Environment: Emerging Markets Queries in Finance and Business, Emq 2013, Procedia Economics and Finance, Vol. 15, pp. 1122-1129, 2014.

[18] KNAPCIKOVA, L., BEHUNOVA, A., BEHUN, M.: Using a discrete event simulation as an effective method applied in the production of recycled material, *Advances in production engineering & management*, Vol. 15, No. 4, pp. 431-444, 2020.

[19] VEGSOOVA, O., KHOURI, S., STRAKA, M., ROSOVA, A., KACMARY, P., BETUS, M.: Using Technical Means and Logistics Principal Applications to Solve Ecological Water Course Accidents, *Polish Journal of Environmental Studies*, Vol. 5, pp. 3875-3883, 2019.

[20] MOZOL, Š., GRZNÁR, P., KRAJČOVIČ, M.: Design of system for more effective data actualisation in simulation, *Acta Simulatio*, Vol. 6, No. 4, pp. 19-22, 2020. https://doi.org/10.22306/asim.v6i4.58

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