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ERP Systems Enhanced with RFID Technology in Furniture Industry

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Abstract: RFID technology is being widely used in most areas that are supported by ERP systems. With the help of RFID tags and readers placed at various locations throughout a furniture company, the presence of various objects in the factory can be monitored in real time. Readers receiving information from RFID tags can transmit it directly into the system and create databases or initiate business processes. The basic resources that can be tracked using RFID are human and machine resources as well as warehoused inventories, spare parts, tools, semi-finished and finished products. The only condition that must be met by the tracked object is that it can be tagged. The furniture industry is continuously growing. With factories expanding to tens of thousands of square metres and employing thousands of workers, knowledge of who or what is where at any given time is very important for optimising plant operations. Being able to gain this knowledge in real time is very useful and saves a lot of resources over the long term. Monitoring of resources in an ERP system using RFID technology is very popular nowadays. The improvement of the implemented solution leads to an ever increasing degree of control. However, it is important to maintain it at an optimal level, because otherwise it may unnecessarily disturb employees in their daily duties or generate more work for them without returning a measurable benefit.

*Keywords***:** RFID, ERP, system, implementation, deployment, production, integration, warehousing, stocktaking, resources, management

INTRODUCTION

Optimising the work of any furniture manufacturing company depends on having information about it. To collect and process such information, IT systems are employed, in which the objects used by the company are defined. Defining objects in the system is the first step and tracking them is a completely separate activity which requires appropriate equipment. By choosing appropriate equipment, it is possible to obtain information on the number and location of various objects on the company grounds.

OBJECTIVE

The objective of this paper is to present potential applications of RFID technology as a source of data supplying ERP systems databases in furniture companies. Both popularly used and less conventional solutions are presented.

ERP SYSTEMS

The creation of different types of registers and inventories has been an integral part of management for thousands of years. Governments have made lists of inhabitants, merchants have made inventories of goods, all the people have made shopping lists. Everyone created some kind of database, although no one called it that way yet.

The 18th century saw the start of the Industrial Revolution in Europe, which changed the approach to production forever. To meet humanity's demand for everything from bread rolls to aeroplanes, factories began to be erected, employing more and more people. As the demand for manufactured goods grew, so did the need to use machines to produce these goods on a larger scale and then transport them.

The aim of every manufacturer is to optimise production. Everyone wants to produce more, at lower cost and in less time. With the growth of furniture factories, which no longer used one but many machines and employed not 10 but 100 people, came the need to manage

them efficiently. And this is where we return to the database mentioned at the beginning. It all started with an inventory of the materials needed for production and then lists were created of the furniture produced, the workers, the machines. Warehouses that were built were divided into smaller areas and named to make communication easier and, needless to say, all this had to be recorded on some sort of a list.

All of those lists were interlinked, the material would go to a specific place in the warehouse, a particular employee would pick it up and pass it to another one from the processing list. The finished product was then returned to its assigned storage location. In this way, a certain system was created based on data from lists. With the development of information technology, it became possible to create all such lists in one machine and define links between them.

In the 1960s the first system to support inventory management was written. Applications of this type were called IC and were used to manage the inventory of a company (Rashid et al., 2002). Further developments in technology in the following decade led to MRP I systems for material requirements planning. At that stage, the systems only managed inventory.

Subsequent stages of MRP systems development led to the emergence of a new system standard in the 1980s - MRP II. The new type of systems allowed not only to plan the use of materials, but also to manage the production process, which involved the allocation of machinery and human resources, as well as distribution. The final step, which gave rise to the ERP class in the 1990s, was the addition to MRP II of functions for managing finance and human resources, purchasing, sales and CRM.

The following diagram presents the areas (Sagegg and Alfnes, 2020) the management of which is supported by all the systems mentioned above.

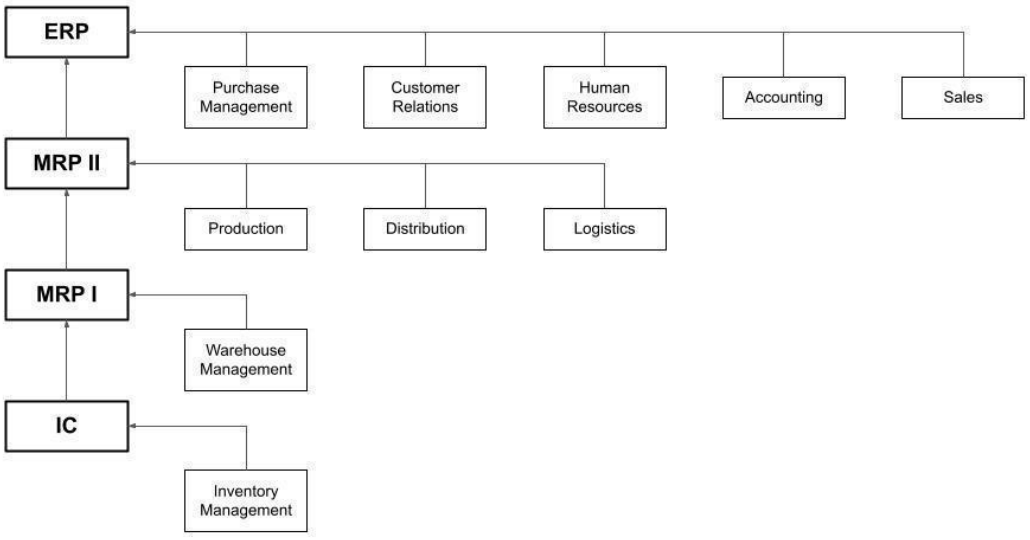

Figure 1. Areas supported by IC, MRP and ERP systems (source: study author)

RFID TECHNOLOGY

In the 1960s, when companies were using IC systems, a new technology for tagging warehouse objects appeared on the market (Booth, 2018). This technology was barcodes used to quickly identify a product and its features using an appropriate scanner. The barcode is a graphic representation of a string of characters. The scanner reads this string of characters and makes it possible to use them for searching information about the object in the system.

Before barcodes became popular, the 1970s came. MRP I systems were in widespread use and employed this technology in the following way. Each warehoused object had its own identification number (ID) in the system. ID numbers were assigned individually in the systems, therefore each barcode created on their basis was unique. By scanning such a code with a device having access to the MRP I system, it was possible to access all data related to a given ID recorded in the system.

Assuming that a country such as Poland is a huge warehouse of its citizens, each of them can be assigned a barcode in the form of their PESEL number. Having access to the State's databases, after scanning this code, it is possible to search for all data on that citizen. However, the barcode itself does not contain any information except the PESEL number, so without access to the database it is not possible to obtain any information using it. Below is an example of the PESEL number stored in the form of barcode in the most popular code 128 format, which is characterised by the fact that it can store all characters from the ASCII set (Masterson, 2005).

Figure 2. PESEL number recorded in the form of a barcode (source: study author).

In the warehouse, such codes in the form of stickers can be used to label everything, from the simplest beam to a tank with chemicals. The use of this technology significantly accelerated the process of taking inventory or picking a customer order. There was no need to enter any data, it was enough to scan the code and to know immediately what object was in front of you.

RFID technology, proposed in the middle of the 70's, became a natural consequence of barcodes as barcodes have one significant disadvantage. In order to read data from them, the data must be within the scanner's light beam. RFID solved this problem. The barcode sticker was replaced by an RFID tag, from which data is read by readers using radio waves for this purpose (Boyer and Verma, 2009).

An RFID tag is made up of an antenna and an electronic circuit with a capacitor as shown in the figure above, when the tag is within the operating range of a reader, which by means of the transmitter antenna generates an electromagnetic wave, the circuit incorporated in the tag converts the electromagnetic wave into electrical energy and stores it in the capacitor. As soon as the label has stored sufficient energy, it begins to transmit a radio signal via the electromagnetic wave. The transmitted signal is received by the reader's antenna, which then filters and decodes the signal to finally read the data stored on the tag (Hunt et al., 2007).

Typically, readers are used that first transmit a signal and then pause to receive responses. Once a tag has sent out its signal and used up all the energy it has collected, it will not have time to recharge and resend the signal, so it is possible to read data from multiple tags in the reader's area at once.

The technology uses many different frequencies which allow to read data from different distances. An additional advantage of RFID tags over barcodes is the possibility of remote overwriting of data stored in the RFID tag.

RFID tags, however, have a downside which is their price. Assuming that the cost of one sticker with a printed barcode is more or less one grosz, RFID tag costs a few dozen groszy. However, we should bear in mind, that RFID provides information about everything within the reach of the reader in a matter of seconds while each single barcode has to be scanned which takes much more time. RFID tags can also be reused many times - they do not have to be attached permanently. However, the continued growth in demand for this technology is driving down the production costs and, consequently, the price of the tags (Turcu, 2011).

USE OF THE TECHNOLOGY IN FURNITURE INDUSTRY

RFID technology is used in most areas supported by ERP systems. With the help of RFID tags and readers located in various places in a furniture company, it is possible to control the presence of various objects on the factory premises in real time (Günther et al., 2008). Readers receiving information from RFID tags can transmit it directly to the system and create databases or initiate business processes.

The furniture industry is continuously growing. With factories expanding to tens of thousands of square metres and employing thousands of workers (Bryson et al., 2015), the information who or what is where at any given time is very important to optimise plant operations. The ability to acquire such knowledge in real time is very useful and saves a lot of resources over a long lifetime.

The main types of resources that can be tracked using RFID are human and machine resources as well as warehoused inventory, spare parts, tools, semi-finished and finished products. The only condition that must be met by the tracked object is that it can be tagged. The more resources under control, the greater the level of awareness of the company's management staff.

HUMAN RESOURCES

Controlling human resources on the premises of a furniture factory is very important, from the knowledge about the workers' presence on the factory grounds and their attendance at the workstation, to the hours worked needed to calculate wages. But not only time and place can be controlled by a system using RFID. Also the access of employees to specific areas of the company.

Each employee should be provided with a standard ID badge with a photo, name and job role in the factory. In addition, an RFID tag should be placed in or on the badge, with recorded information about the employee's ID number from the ERP system. The ERP system may have information in its databases about the employee's working hours and days, the assigned workstation and team, access to certain areas of the factory, and skills to operate a particular type of machinery (Monk and Wagner, 2012).

Entry to the site is possible either on foot or by car or truck. In the first case, the building allowing entry from outside should be equipped with gates with readers. When an employee with his/her ID badge approaches the door, the reader should scan the information from the RFID tag and transmit it to the system for identification. If the person is identified in the system and has access to the area behind the gate, the gate will open. Otherwise the gate will remain closed. It is also possible to prepare special visitor IDs which can be assigned with appropriate permissions and accompanying persons with whom visitors can move around the premises. Given these two cases, gates should be prepared both for groups and for individual employees.

When employees arrive to work by car, the guardrail at the entrance should only open when a reader verifies that the person in the car has an RFID tagged card and the appropriate access rights.

Using these mechanisms, the time of the employee's arrival on the premises can be recorded in the system. In case an employee is on sick leave and is not allowed to be on the factory premises at that time, their access in the ERP system is automatically blocked after entering the medical leave details and the person cannot enter the factory premises.

When leaving the company grounds, anyone in possession of an RFID tagged card can exit the premises without restrictions, but the reader must read the time of exit in order to count the hours worked that day. Workstations can be equipped with readers both to monitor the number of available seats at desks in the case of office work and at machines in the case of operators. When operating machines, additional security can be implemented using RFID tags and an ERP system by entering a condition into the system which will have to be fulfilled before the machine can be started. For this purpose, it is sufficient to define in the employee file in the

system a qualification to operate a given machine and to limit the machine operators to employees who have such a qualification.

A good example from the furniture industry is a CNC machine tool, whose operator should be properly trained before starting to use it. The operator has received material for cutting and can place it on the machine, but when the machine is instructed to start the process, the system will verify the operator's permission based on the ID number assigned to his/her RFID tagged card. If there is no information in the system that this operator has received the required training, the machine will not start.

Of course, this is only an additional security measure, the ERP system will assign such a job only to a person who has the necessary authorisations and will not allow an employee without the necessary qualifications to operate this type of machine.

TOOLS AND EQUIPMENT

Enabling proper management of machine resources requires knowledge of their current location, so all machines can be equipped with RFID tags and their storage locations with readers. Thanks to such a solution, it will be possible to monitor the presence of transport vehicles such as forklifts and plan their operations (Ruan and Hu, 2011).

At the end of each shift, the system can verify that all machines have returned to their proper location. Also vehicles can be equipped with RFID readers and, on a similar basis as in the case of workstations, the rights of the person who wants to use the vehicle and of the current user can be verified. ERP system planning the work of equipment and machinery can take into account the working hours of the vehicle as a piece of equipment assigned to a particular user.

Similarly, the system can work with tools. Preparing appropriate storage places for tools will allow tracking their status and users. If a tool is misplaced somewhere in the plant, it is sufficient to check the sensors in a given area to see whether the tool is at any of the workstations. Each individual workstation can also be equipped with an individual tool kit. If any particular tool disappears after scanning the workstation at the end of a shift, the name of the worker who used it will be known.

If a tool wears out or breaks down, it can be placed in a dedicated box with a built-in reader, at the end of the shift. It will then be known which workstations are missing tools and why. Receiving a response from the tag via a sensor in such a box will initiate the process of repair or replacement of the tool by the relevant team, who will be informed of the need to do so by the system.

Tool tagging can also ensure that tools are not carried off site, as an exit gate will not let out a worker who is carrying a tool (Kahn, 2008).

LOGISTICS

Suppliers of production materials can be provided by the company with their own RFID-tagged cards, so that the supplier information can be read out at the entry and linked to a specific order. In this way, the driver will be able to obtain information about the goods receipt area in the factory. The system will also be able to choose the dock nearest to the final storage location.

When a reader is mounted at the dock, the system will be able to send a message to the warehouse team to collect the delivery.

Because of this possibility, suppliers provide their goods with RFID tags of the company, which should make them available if they cannot be obtained as part of their business operations.

The delivery should preferably be first unloaded in an area dedicated to inspection of goods upon receipt. When the goods are placed in the inspection zone, the reader mounted there will check which stock items have been delivered and the system will then compare them with the order to verify its completeness (Jones and Chung, 2007).

The ERP system will generate transport orders for the received goods and assign operators, transport equipment and the goods they should take. When a sensor on the vehicle checks which goods have been loaded on it, the information about the possibility of executing the transport job will be transmitted to the system. The system will assign appropriate locations which have been predefined in the system, with their own ID numbers, where the goods should be placed and will show the optimum route to the vehicle operator.

In the furniture industry, goods are usually transported on pallets, on which boxes with materials or materials wrapped in foil are placed. Companies, which do not use RFID technology, operate on system-packed materials, which means, that each transport unit, such as a pallet, must be packed in the system and its content must be recorded. Such a packed pallet can be transported to the warehouse, but in order to retrieve anything from this pallet, it must be first unpacked using a scanner. RFID technology saves time, because instead of monitoring the status of the pallet during the entire transport, it is only checked at the beginning and after the material has been delivered to the site.

The availability of storage locations is usually monitored by the ERP system, readers monitor the status of these locations in real time. Based on the details and dimensions of the materials and dimensions of the storage space, the system can calculate how much more stock will fit in the space (Sharma and Mutsaddi, 2010).

STOCKTAKING AND INVENTORY MANAGEMENT

The most labour-intensive of all administrative tasks in a company is the stocktaking process. By using RFID technology and an ERP system, it is easy to compare the system status with the actual status. The only thing to do is to install readers at all storage locations (Skrabec, 2012). Care must be taken to ensure that the individual storage locations are sufficiently isolated from each other so that there is no duplication of readings.

A specific time should be set at which no deliveries are accepted and no material is released for production. At this time, a signal is sent from all the warehouse readers in the company and the stock is compared with the obtained response. Any inaccuracies are forwarded to the responsible persons who will then clarify all potential shortages or surpluses.

In the furniture industry, many stored objects are not suitable for RFID tagging, such as screws, adhesives or threads. In this case, the packaging in which these objects are stored must be introduced into the system. Such packaging is tagged and each time a nominal amount of material equal to the contents of the packaging is consumed, the item is removed. Warehouse staff only need to remember to discard used packaging so that it does not generate errors.

Packaging can also be defined in terms of pallets containing many different materials, with the pallet being given its own ID and tag. This is particularly important for pallet containers.

On the basis of reader data, it is possible to monitor the status of materials and maintain the so-called "mini-max" stock rules, i.e. minimum or maximum quantities of materials which should be in a given warehouse space or storage location (Wild, 2002). In the event of going below the pre-set value, information is generated for the purchasing organisation in the system about the need to place an order. On the other hand, material transports are not directed to locations where maximum limits of material quantities would be exceeded.

MANUFACTURING

ERP systems using production planning modules and routes assigned to given products generate unique production orders, which are assigned to employees, machines and production lines. Under the production order, the amount of materials needed to execute it is calculated based on the product structure of the given type of goods. The system creates transport orders whose final completion time is aligned with the production start time (Sagegg and Alfnes,

2020). Each production line or production workstation must have its own storage place for materials required for the production processes.

In order to present the different possible approaches for the furniture industry, it is worth considering here two situations from two different production lines. The first will be a production line for sofa frames and the second will be a production line for latex foam mattresses.

The production line for sofa frames uses mostly countable parts, which are usually prepared in a special box for a given workstation. Planks, beams, screws, nuts, washers, upholstery staples and glue are delivered and placed in the box. Planks and beams can be tagged, but screws, nuts, staples, washers and glue cannot. For this reason, mini-max rules should be defined at the workstation to keep the number of tacked packages of the materials at the level of X + 1 depending on the consumption over a defined period of time.

In this case, it is not necessary to deliver all the materials at once, they can be brought in batches. Work on a production order can begin when a set of materials for the first item from the order is available in the box next to the workstation for retrieval by the employee (Jacobs et al., 2011).

However, things are different when it comes to the latex mattress production line. Mattresses made of this material are cast in moulds, then left to rise in an oven, removed from the moulds and cooled. The materials for their production are chemicals stored in pallet tanks, which are transported by warehouse staff to the production line and connected to mixers. In this case too, mini-max rules at the level of pallet tanks must be used, which will allow the mixers to maintain constant access to the material.

PRODUCTION REPORTING

After the production of one piece of a product from an order has been completed, this piece should be placed in the delivery bay of the production line, where the furniture will be scanned and the system will record the material issue according to the scanned items (Kletti, 2007). It is good practice to provide a second location at the production line for materials that are written off as waste during production. The information from both readers will then serve as the basis for recording the material issue data.

Recording material issue in the system involves adding one item of product to the stock. Of course, you can also use the system to report entire batches. One of the tags on the materials should be overwritten with the product ID value. You should select one that appears only once in each piece. All other tags used to manufactured the product must be overwritten with a zero value.

In the case of furniture production, which is sold in self-assembly boxes, scanning of packages can facilitate verification that the contents of the box correspond to the product structure.

Also in the case of furniture made to order which does not have a uniform product structure because it is customisable, it is possible to verify the materials used with the scanner and report the exact configuration.

STORAGE

The process of handing over the finished goods to the warehouse begins when the RFID tag is scanned by the reader at the point of transfer of the production line. In this case, it is worth using mini-max rules, which can be set for each finished product made on a particular production line. When using this solution, the warehouse is not informed about each piece ready for entry into the warehouse, but only about the finished sets.

As soon as the reader reports that the maximum quantity of a given product is available in the picking area of the production line, an order will be created for the warehouse staff to transport a set of products to the warehouse. After the warehouse staff accept the order and start

working on it, the system will allow collection of the products covered by the order if a worker or a vehicle assigned to the order appears within the range of the reader. Otherwise, the system will display an appropriate message.

The order will contain information on the storage location where the products should be placed. After transporting the finished goods to their destination, the reader will record their position and send the information to the system, which will close the order (Jones, 2019).

A very good solution in the furniture industry, where a lot of furniture for assembly by the customers is produced, is to use a conveyor belt on which boxes with finished products are placed (Hompel and Schmidt, 2006). A reader can be mounted at the end of the conveyor belt to read the information about each passing box and enable the system to direct it to the appropriate collection point (McGuire, 2009).

Such a solution allows to minimize the number of readers needed (Ustundag, 2012) because the system can count how many boxes have been forwarded to each location and thus monitor their status. When the maximum number of boxes in a given location is reached, according to the calculation made, the system will generate a transport order and warehouse staff will collect the goods from the indicated place, previously verifying their status with a hand-held reader or truck-mounted reader. An alternative way of verification would be to transport the goods to the indicated destination and allow the reader of the storage location to perform the check. However, in this case, control over the goods is temporarily lost.

DISTRIBUTION

Preparing finished products for shipment is the reverse process to receiving ordered materials into the warehouse. After receiving an order from the customer, the system prepares a transport order for products to be delivered to the loading dock area and an order for picking the goods after preparation by the transport team. Controlling the area with an RFID reader allows one to keep track of the readiness status of the order (Fernie and Sparks, 2004).

When the reader reports that the order is complete and there are no additional products in the monitored area, the order is closed.

The reader at the dock will await the arrival of the transport vehicle and as soon as it is within its range, the warehouse will be informed that loading can begin. When the reader at the dock records that a complete order is loaded on the truck, the loading is complete and the transport begins. The system will inform the customer that the order has left the warehouse (Ray, 2011).

IMPLEMENTED SOLUTION

An example of the use of RFID integrated with the ERP system is the process of controlling the inventory of a mattress factory belonging to the CORRECT limited partnership, a company from COM40 Group. The COM40 company started the implementation of the Oracle EBS ERP system in 201 and I joined the project while it was already in progress, in September 2017. As one of two persons, I was responsible for the quality of the system implementation from the business-system analysis perspective, in respect of the discrete manufacturing module and the product structure. The implementation project, which was planned for several years, included the integration of the ERP system with the signals transmitted by the RFID technology already in use at the company at that time.

The COM40 Group is one of the largest suppliers of upholstered furniture and mattresses to IKEA. A semi-finished product used in the production of polyurethane foam mattresses is manufactured on site, at the CORRECT factory. This semi-finished product is a block of polyurethane foam with a rectangular cross-section with sides as long as 2 metres. Most important, however, is the length of the whole block, which can be up to 30 metres. With such dimensions, the weight of the warehoused object is several tonnes.

Such blocks are stored in a number of columns, with up to 7 blocks placed one on top of the other. Due to the difficulty in accessing the higher blocks, the use of ordinary barcodes to identify each block and its properties is impossible. That is why RFID technology was used. Each block has its own individual tag. When there is a need to carry out a stock check, a signal is sent from the readers, to which the RFID tags on the blocks respond. In a few seconds, a list of all blocks and their characteristics is available on the user interface.

The use of this technology allows for error-free, quick and accurate assessment of the warehouse stock. For this reason, the company decided to implement the RFID technology and integrate it with the ERP system. For companies of this type, the greatest constraint is always time.

CONCLUSION

The use of RFID technology as an information gathering tool for the ERP system offers many possibilities, which can be universally adapted to the nature of the production of a given enterprise. Due to the size of furniture industry products, maintaining RFID tags on materials and finished products is not an obstacle.

This technology saves time, which is the basic factor in any kind of production. Taking stock stops the factory operations for the time of its duration. Having the ability to do so in a shorter period of time is a significant benefit to the company. The same with picking orders and receiving deliveries of materials on stock. The possibility of controlling, in real time, the human and machine resources is also a source of considerable savings of time, which is the most important asset in any company.

An important aspect when implementing an ERP system is the degree of control that the system should have over the operations of the enterprise. An inadequately adjusted system may interfere with the operations and thus slow down the work of the factory. Therefore, special attention should be paid to the implementation stage, to make sure that the system is as self-sustainable as possible and its performance is optimized.

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Streszczenie: Technologia RFID znajduje zastosowanie w większości obszarów objętych wsparciem systemów ERP. Przy pomocy etykiet RFID i czytników umiejscowionych w najróżniejszych miejscach w przedsiębiorstwie meblarskim można w czasie rzeczywistym kontrolować obecność przeróżnych obiektów na terenie fabryki. Czytniki odbierające informacje z etykiet RFID mogą przekazywać ją bezpośrednio do systemu i tworzyć bazy danych lub rozpoczynać procesy biznesowe. Podstawowymi zasobami, które można poddać obserwacji przy pomocy RFID są zasoby ludzkie i maszynowe oraz magazynowane zapasy, części zamienne, narzędzia, półprodukty i wyroby gotowe. Jedynym warunkiem, który musi spełniać monitorowany obiekt jest możliwość oklejenia go etykietą. Przemysł meblarski rozwija się nieustannie, ze względu na rozbudowę fabryk do rozmiarów dziesiątek tysięcy metrów kwadratowych i zatrudnianiu w nich tysięcy pracowników wiedza o tym kto lub co gdzie znajduje się w danym momencie jest bardzo istotna dla optymalizacji pracy zakładu. Możliwość zdobycia tej wiedzy w czasie rzeczywistym jest bardzo użyteczna i pozwala oszczędzić wiele środków przy długim okresie eksploatacji. Monitorowanie zasobów w systemie ERP przy pomocy technologii RFID jest bardzo popularne w dzisiejszych czasach. Ulepszanie zaimplementowanego rozwiązania doprowadza do coraz większego wzrostu kontroli. Istotną kwestią jest jednak utrzymanie jej optymalnego poziomu, ponieważ w przeciwnym wypadku może ona niepotrzebnie przeszkadzać pracownikom w ich codziennych obowiązkach lub generować im większą ilość pracy bez zwracania wymiernej korzyści.

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