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The Application of New RFID System in Logistics Warehousing Management - Taking the Automobile Industry as an Example

Harjoni[1*], Erwinsyah Satria[2], Sarwan[3], Muh Ibnu Sholeh[4], Nyoman Gunantara[5]

[1]IAIN Lhokseumawe, Aceh, Indonesia
Email: harjonidesky@iainlhokseumawe.ac.id
[2]Elementary School Teacher Education, Universitas Bung Hatta, Indonesia
Email: erwinsyah.satria@bunghatta.ac.id
[3]State Islamic University (UIN) KHAS Jember, Indonesia
Email: sarwaniain15@gmail.com
[4]STAI Kh. Muhammad Ali Shodiq Tulungagung, Indonesia
Email: indocelllular@gmail.com
[5]Electrical Engineering, Universitas Udayana, Indonesia
Email: gunantara@unud.ac.id
*Correspondence author: harjonidesky@iainlhokseumawe.ac.id

Abstract: In order to solve the problem of logistics warehousing management, this paper proposes a new RFID system in the application of logistics warehousing management. As a non-contact automatic identification technology, RFID can automatically identify the target object and obtain relevant data through RF signals, and can identify high-speed moving objects and multiple tags in various harsh environments. This advantage is changing the management mode of traditional warehouse, improving the efficiency and accuracy of management, and increasing the profit space of enterprises. Through experiments, this paper discusses the research and development of RFID in warehouse management system. The experimental results show that RFID technology can use spatial coupling, i.e. electromagnetic field, to transmit information, and radio frequency generally identifies and communicates through 1 to 100g Hz radio waves. Conclusion: RFID technology can accurately store, allocate on time, effectively use storage space and save storage costs.

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Keywords: Automobile; Internet of things; RFID technology; Logistics management system; Warehouse management system

1. Introduction

The times are developing and progressing. The development of the logistics industry is also keeping pace with the times. Its automation level is also constantly improving. The adoption of new equipment and technological innovation are often used to continuously improve the automation level. In the development of the logistics industry, the introduction of bar code technology has become a small milestone in the industry. The convenient and easy to learn operation has greatly improved its work efficiency. The timeliness and accuracy of inventory management have made the application of this technology in the logistics industry more extensive and popular. However, with the wide use of this technology, some shortcomings of the traditional bar code system have become increasingly prominent. Because the bar code is exposed to the outside, it is easy to be polluted and damaged. At the same time, it must be scanned one by one during scanning. This way of working makes the workload of goods in and out of the warehouse relatively large and time-consuming. At present, many warehouses still use traditional bar codes, which requires the staff to scan the bar codes one by one with the scanner, so the work efficiency can be imagined. Of course, the management of this warehouse cannot keep up, and informatization and automation are even more difficult. Therefore, in order to improve efficiency and win more profit space, we must carry out field to field technological innovation. Modernization, efficiency and accuracy have become the trend and need of the development of modern logistics industry. Therefore, some new technologies have been developed. RFID technology can realize the whole process information management of warehousing, assembly, distribution and other links in the warehousing and logistics industry, which has attracted the high attention and pursuit of research departments and relevant enterprises.

2 Literature review

Prinsloo & Malekian [1] said that RFID (radio frequency identification) technology is a modern communication technology, which rose in the 1990s. Because it can identify data through long-distance radio frequency without actual contact, it is widely used in enterprise production and social life. Al-Fuqaha [2] others said that the structure of RPD system generally consists of three parts: application software system, reader and electronic tag. The application software system is generally composed of relevant data analysis software, which

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may be a single processing software or multiple processing software working at the same time. It [3] said that application software systems are generally connected to readers, and provide decision-making suggestions for enterprise organizers by analyzing and processing the data provided by readers. It said that readers collect and read RFID technology, which can use spatial coupling, electromagnetic field, to transmit information. Radio frequency generally carries out identification communication through 1-100g Hz radio waves [4]. Stambaugh said that due to the wide application fields of RFID technology, there will be a broader market in the next 10 years [5]. Berry said that in terms of the market share of commercial malls, relevant people pointed out that in the next five years, the market opportunities brought by RFID technology and related derivative technologies will reach 30billion US dollars. At the same time, the demand for optical automatic recognition, human automatic recognition, cloud service system, internal software, computers and other industries in the Internet and science and technology field will continue to rise [6]. Therefore, RFID technology will be more widely used in the future medical, transportation, health, commercial, military, telecom operators and other fields [7]. Bolomey and others said that RFID technology relies on two originals to control, detect and track [8] structurally. Whitehouse and others said that the radio signal sends the attached data through the frequency modulated electromagnetic field, and the receiver receives and exports the data. The technology of realizing long-distance information reading through wireless signal is different from bar code technology. RFID technology has become the largest leader in automatic identification technology in the industry due to its advantages of long readability, large data volume, simple operation, stability and durability[9]. Valley stated that tags in RFID technology can be flexibly set up to send data from RFID tags to RFID read and write using weak radio frequency signals [10]. The research on the application of the new RFID system in logistics warehousing management is shown in Figure 1.

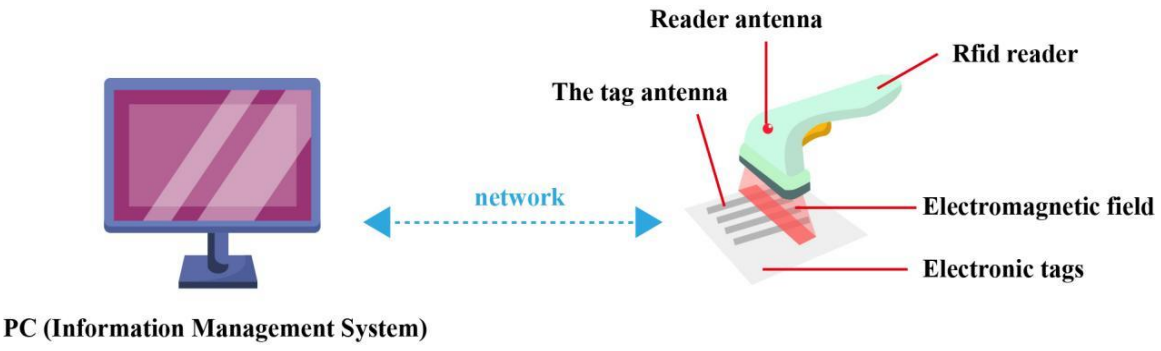

Figure 1. Research on the application of new RFID system in logistics warehousing management

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3 Method

The structure of RFID system generally consists of three parts: application software system, reader and electronic tag. The application software system is generally composed of relevant data analysis software, which may be a single processing software or multiple processing software working at the same time [11]. The application software system is usually connected with the reader to provide decision-making suggestions for enterprise organizers by analyzing and processing the data provided by the reader. In the RFID system of some enterprises, there will also be RFID Middleware for docking and processing the data and other information between the reader and the application software system [12-13]. Readers are usually composed of a variety of components. Some readers use built-in or external antennas, coupling devices and chips. In terms of structural design, they are also fixed or mobile in addition to handheld. Reader can play a connecting role in the whole RFID system. Electronic tags, also known as transponder (tag), are generally composed of coupling elements, antennas and chips, which can be roughly divided into passive and active [14]. In the active electronic tag, the RFID tag carries an active power supply, so it has a wide radiation range, strong signal stability and high information security when transmitting signals. The passive RFID tag has no power supply inside, so its fixed cost is relatively low and its service life is longer. The specific composition of RFID and the internal diagram of the tag are shown in Figure 2 and figure 3.

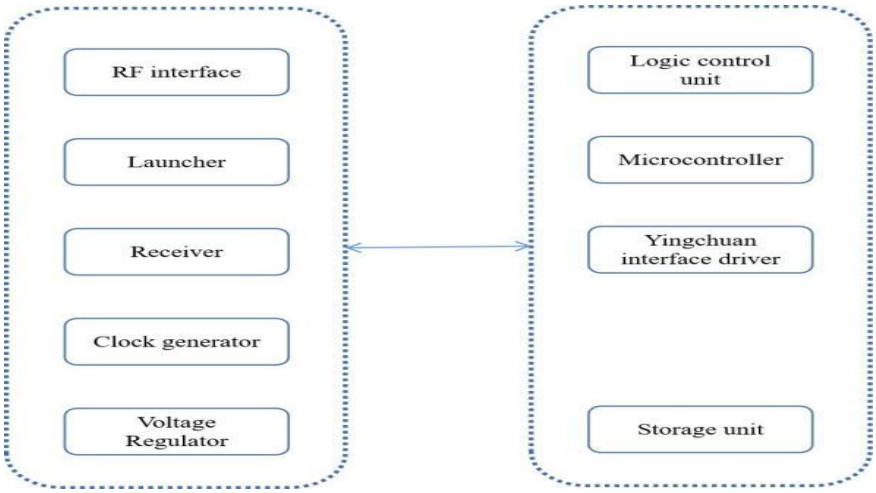

Figure 2 Composition of RFID system

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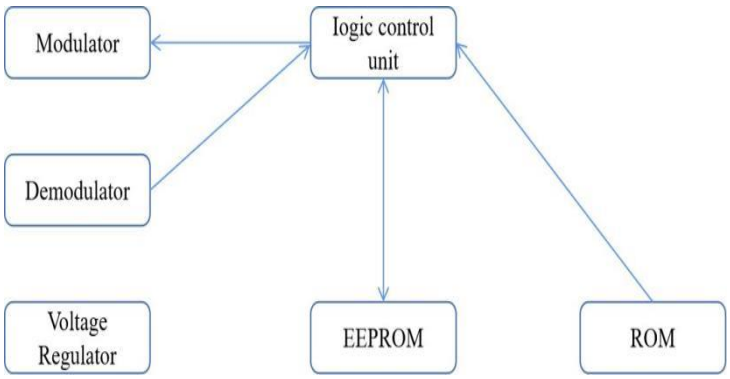

Figure 3 Internal drawing of RFID tag

When the enterprise does not adopt RFID technology, it is assumed that the order quantity (production quantity) is Q and the response efficiency from warehouse to shelf is ξ. Then the profit function under centralized decision-making is shown in formula (1):

$$\prod 1 = p_x \min(bQ, x) + p_s(bQ - \min(bQ, x)) - p_c Q \quad (1)$$

Where $p_x \min(bQ, x)$ is the sales revenue, $p_s(bQ - \min(bQ, x))$ is the residual value at the end of the sales season, and $p_c Q$ is the commodity cost. The expected sales volume is shown in formula (2):

$$E\min(x, bQ) = bQ - \int_0^{bQ} (bQ - x) f(x) dx \quad (2)$$

Substitute formula (2) into formula (1) to obtain the expected function of profit as shown in formula (3):

$$\prod 1 = p_x bQ - (p_x - p_s) \int_0^{bQ} (bQ - x) f(x) dx - p_c Q \quad (3)$$

The second derivative of $\prod 1$ with respect to Q can be obtained as shown in formula (4):

$$\frac{\partial^2 \prod 1}{\partial Q^2} - (p_x - p_s) b^2 f(Q) < 0 \quad (4)$$

Therefore, in the case of centralized decision-making without RFID technology, the optimal profit function $\prod 1$ is a concave function about the order quantity Q, and there is a unique optimal solution Q1 to maximize the profit of the supply chain. If the first derivative of $\prod 1$ with respect to Q is equal to zero, the optimal order quantity can be obtained as shown in

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formula (5):

$$F(Q1)=\frac{p_x b-p_c}{(p_x-p_s)b^2} \quad (5)$$

Since the demand $x\in N(\varepsilon\mu,\sqrt{\varepsilon}\sigma)$ at this time, as shown in formula (6):

$$\frac{x-\varepsilon\mu}{\sqrt{\varepsilon}\sigma}\in N(0,1) \quad (6)$$

As shown in formula (7):

$$F(Q1)=\phi\left(\frac{Q1-\varepsilon\mu}{\sqrt{\varepsilon}\sigma}\right) \quad (7)$$

According to formula (6), formula (7) is as shown in formula (8):

$$Q1=\varepsilon\mu-z_1\sqrt{\varepsilon}\sigma \quad (8)$$

Where z1 is shown in formula (9):

$$z_1=\phi^{-1}\left(\frac{p_x b-p_c}{(p_x-p_s)b^2}\right) \quad (9)$$

The maximum profit obtained by substituting formula (8) into formula (4) is shown in formula (9):

$$\prod 1^*=(p_x b-p_c)\varepsilon\mu-(p_x-p_s)b^2\sqrt{\varepsilon}\sigma\varphi(z_1) \quad (9)$$

After adopting RFID technology, on the one hand, it can accurately detect the quantity, location and other information of goods on the shelf, and accurately obtain the quantity of goods lost, so that the shelves can be replenished in time without shortage. On the other hand, the temperature and humidity environment of the warehouse shall be monitored and adjusted at any time to avoid the deterioration of goods during storage and make the loss of goods become zero. Therefore, at this time, the shelf replenishment efficiency ξ= 1, and there is no 1% loss at the end of the sales season. The profit function is shown in formula (10):

$$\prod 2=p_x\min(Q,x)+p_s(Q-\min(Q,x))-p_cQ-p_bQ \quad (10)$$

Where $p_x\min(Q,x)$ is the sales revenue, $p_s(Q-\min(Q,x))$ is the residual value at the end of the sales season, p_cQ is the commodity cost, and p_bQ is the RFID tag cost. The

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expected sales volume is shown in formula (11):

$$E\min(x,Q)=Q-\int_0^{bQ}(Q-x)f(x)dx \quad (11)$$

Substituting formula (10) into formula (9), the expected function of profit is shown in formula (12):

$$\prod 2=p_xQ-(p_x-p_s)\int_0^0+(Q-x)f(x)dx-p_cQ-p_bQ \quad (12)$$

The second derivative of the expected function $\prod 2$ with respect to Q can be obtained as shown in formula (13):

$$\frac{\partial^2\prod 2}{\partial Q^2}=-(p_x-p_s)f(Q)<0 \quad (13)$$

Therefore, in the case of centralized decision-making using RFID, the optimal profit function $\prod 2$ is a concave function about the order quantity Q, and there is a unique optimal solution Q2 to maximize the profit of the supply chain. If the first derivative of Q2 with respect to q is equal to zero, the optimal order quantity can be obtained as shown in formula (14):

$$F(Q2)=\frac{p_x-p_c-p_b}{p_x-p_s} \quad (14)$$

After RFID is adopted, the market demand is the time demand, as shown in formula (15):

$$x\in N(\mu_x,\sigma_x) \quad (15)$$

Therefore, as shown in formula (16):

$$\frac{x-\mu_x}{\sigma_x}\in N(0,1) \quad (16)$$

As shown in formula (17):

$$F(Q2)=\phi\left(\frac{Q2-\mu}{\sigma}\right) \quad (17)$$

According to formula (17), formula (14) is as shown in formula (18):

$$Q2=\mu+z_2\sigma \quad (18)$$

Where z2 is shown in formula (19):

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$$z_2 = \phi^{-1}\left(\frac{p_x - p_c - p_b}{p_x - p_s}\right) \quad (19)$$

By substituting formula (17) into formula (11), the maximum profit of the supply chain is shown in formula (20):

$$\prod 2^* = (p_x - p_c - p_b)\mu - (p_x - p_s)\sigma\varphi(z_2) \quad (20)$$

It can be seen that using RFID technology to manage the shelves, on the one hand, it can alert the shortage of inventory in real time, speed up the timely replenishment rate of shelves, make $\xi = 1$, and increase the optimal order quantity. On the other hand, it can avoid unnecessary waste and loss in the stored procedure.

4 Result and Discussion

Randomly select 8-bit tag ID, simulate three algorithms of JDS, IPA and RIPA, program and simulate the algorithm through C language, and select random and orderly ID tags. The total times and total bits of reader query and tag response are counted respectively, and the results are shown in Figure 4.

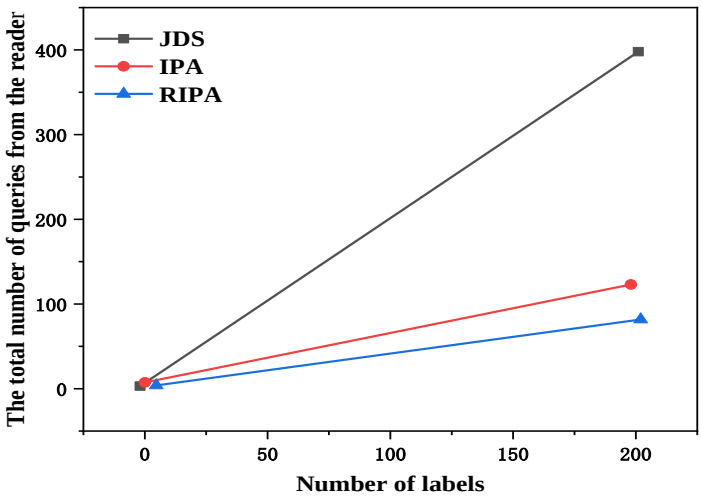

Figure 4 Total number of reader queries

With the continuous improvement of automatic detection technology functions, RFID technology has also achieved good results. At present, in various fields of automatic

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identification technology. Through the comparative analysis of barcode, optical signal recognition, voice recognition, fingerprint recognition, contact IC card and radio frequency identification, the relevant technical parameters are shown in Table 1 [15-16].

Table 1 Comparison and analysis of automatic identification technology

Parameter	Bar code	Optical character recognition	Speech recognition	Fingerprint identification	Contact type	Radio frequency identification
Data volume (bytes)	1-100	1-100	-	-	IC card	16- 64k
Read mode	Laser beam scanning	Photoelectric conversion	Machine reading	Machine reading	16-64k	Wireless communication
Recognition speed	Less than 4S	Less than 3S	More than 5S	5-10s	Electric erasure	Less than 0.5s
Identification distance	Near	Very close	Very close	Direct contact	Less than 4s	Far
Machine readability	Good	Good	Time-consuming	Time-consuming	Direct contact	Good
Manual readability	Constrained	Probably	Impossible	Impossible	Good	Impossible
Confidentiality	Nothing	Nothing	Good	Good	Impossible	Good
Humidity effect	Very serious	Very serious	-	-	Good	No impact
Light masking effect	All invalid	All invalid	-	Probably	-	No impact

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Direction position influence	Very small	Very small	-	-	One direction	No impact

Through the comparative analysis of Table 1, the following advantages are summarized for RFID technology, as shown in Table 2.

Table 2 Advantages of RFID Technology

Specific areas	Advantage
Contact	Completely non-contact, fully automated scanning and reading technology
Data volume	Large amount of data is received, which can receive detailed information such as specifications and quality of production materials
Information processing speed	The processing speed is fast, and the receiving and feedback channels are unblocked through radio frequency
Confidentiality	With high confidentiality, wireless channel encryption can be performed to effectively prevent data interference and theft
Identification distance	The identification distance is long, and the general detection distance can reach tens of meters
Adaptability	Strong adaptability, able to work in multi link and complex environment
Versatility	When the system is used, there are various docking interfaces, which can realize multi-objective and multi-purpose operation
Reliability	Strong reliability and easy and convenient operation

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For automobile parts processing enterprises, the logistics warehousing business of the company has many special features: the warehousing operation efficiency is high, and the automobile itself belongs to a whole product. The lack of any part in the assembly process will lead to the failure of normal assembly of the whole vehicle, resulting in production difficulties, problems in achieving the enterprise goals, and losses to the enterprise [17]. At the same time, consumers in 4S auto retailers and medical stores have high demand for nursing care, so enterprises have high requirements for performance and stability. The level of different applicants is huge. Due to the wide variety of auto parts, there are many differences in the same category. As the only domestic manufacturer of a single model, the company has a large nationwide demand, and different customers have different types of needs. So there are many tasks in the process of distribution, surplus and return. Without good management, the day-to-day operations of a business cannot be successful [18-19].

With the high demand for high-quality products, automobiles, as a stable material in people's daily life, affect the personal safety of consumers. Therefore, the quality of auto parts must meet the standards from production to distribution, storage to sale. As automotive equipment has high requirements for fast delivery in the production process, the company's customers also have high requirements for fast delivery. Failure to maintain fast distribution will affect the reputation and long-term development of the business[20-21]. Internal and external management of the company is difficult. Taking the truck manufacturing industry as an example, there are 24,000 employees, many design and operation details, many customers, and many positioning. In the aspect of RFID tag selection in EPC system, the combination of barcode and RFID tag is used for tag classification. Due to the variety of parts and the large number of single products of the auto parts manufacturer, all parts are classified according to the standards in industrial production when selecting labels. All components are roughly divided into engine system, fuel system, cooling system, lubrication system, body and chassis system, wheel system, suspension, braking system, ignition system, starting system, charging system, lighting quality, measurement system, electrical control system., infectious diseases, etc. Due to the diversity of the system, these groups are divided into 8 groups: the machine group and the other 8 groups. Each subgroup is divided into 8 to 20 subgroups. The 8 category codes are defined as T01 to t08, the subcategories in the category are defined as 01 to 99, and the subcategories in the category are defined as 01 to 99, that is, the registration t010101 that generates t089999. These tags are marked with RFID tags, as well as many different identities and products of the same material. One of the following paragraphs is the classification table of auto parts of a company. As shown in Table 3.

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Table 3 Supply and demand quantity of various types of parts of an automobile assembly company

number	name	Inventory quantity x1	In transit quantity x2	Demand quantity Y1	Supply demand difference Z
T01	Engine system				
T0101	Engine system				
T010101	Belt (chain)	5627	421	454	5594
T010102	Camshaft	15243	135	1543	13835
T010103	Connecting rod	34534	373	4334	30573
T010104	Crankcase	12315	0	438	11877

After the material label information is written, the RFID label and barcode label are basically completed. Before parts transportation, divide the internal procedure modules of the existing company's warehousing according to the EPC system of RFIF, and select the transportation point according to the optimal principle.

A system is ultimately for users. The quality of a system depends not only on whether the system can meet all the required functions. Many administrators and decision makers do not understand the top operating procedures of computers, and their access to information and decisions can be made through the software provided to them. Whether the information provided by the system meets the needs of the decision maker for review, whether the decision has been made or is made by an individual, the decision can be sent to any staff member who receives the decision [22-23]. The completeness of information provided by a system determines the correctness of decision-making. In order to improve the security of the system and better manage users at different levels, the system is generally set with permissions. Setting different permissions according to different users can not only better manage users, but also further strengthen the security and reliability of the information system. Users are most concerned about the security of a system. An insecure system will lead to information

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leakage, data theft, etc. Traditional enterprises use bar code technology more. The production cost of bar code technology is low, but bar code not only has limited functions, but also bar code technology cannot be reused. Compared with RFID technology, which is more expensive to produce, the initial investment cost is higher, but the electronic tag not only has a large amount of information, but also can be reused. For an enterprise to make a long-term plan, the electronic tag will save a lot of costs. For the input of sensor equipment, the traditional enterprise storage, especially for the commodities sensitive to environmental factors, the annual loss of deterioration of commodities due to environmental changes is inestimable [24-25]. Traditional enterprises often see examples of commodity corruption due to temperature and humidity. The use of sensors enables enterprises to strictly predict and control the environmental factors of stored commodities, and take timely measures when the environment changes. The traditional wireless network technology is generated by transmitting wireless WiFi signals through wireless routers. Due to the very small WiFi coverage, the entire warehouse needs to use a lot of wireless routers and arrange network cables, resulting in the complexity of the whole network system and the complexity of server processing information. There are wired information and wireless WiFi information [26]. The use of optical wireless switching technology can avoid the above problems. Because of its ultra wide coverage and mixed information processing ability, optical wireless technology can well deal with the current network technology problems and bring great economic convenience to enterprises. Therefore, through the economic analysis of hardware facilities, the research and development of intelligent storage system based on the Internet of things is completely economically feasible. First, check whether the basic information of the goods is basically consistent with the required warehousing information. If it is inconsistent, the goods will be rejected. If it is consistent, then analyze the storage location of the goods, find out the warehouse, shelf, layer and other information corresponding to the goods, and obtain the corresponding information from the automatic AGV trolley and automatic stacker in the warehouse to store the goods in the corresponding correct storage location. Compared with the traditional warehousing, it obviously improves the accuracy of warehousing goods, and can quickly go to the storage location of goods while warehousing, which greatly improves the efficiency of warehousing. The warehousing flow chart of the intelligent warehousing management system based on the Internet of things is shown in Figure 6.

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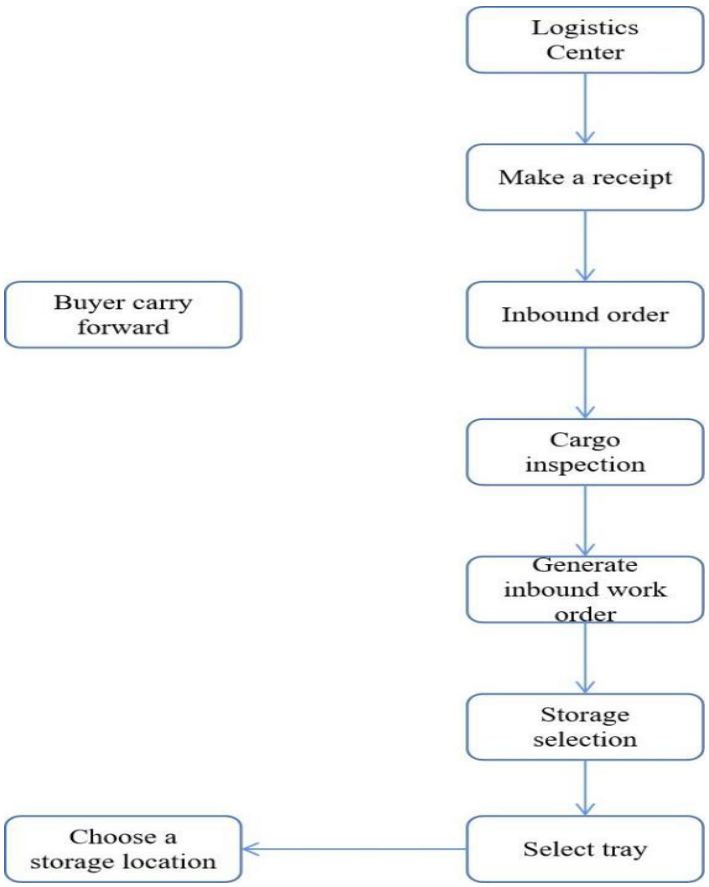

Figure 6 Warehousing flow chart of intelligent warehousing management system based on Internet of things

The logical structure design of the database is based on the conceptual structure design to reflect the logical structure characteristics of the database [27-28]. The MySQL database is used in this paper. Its logical structure is a relational model database. The relational model generally uses two-dimensional tables to store data, which clearly shows the attributes and constraints between data. In the process of database design, the conceptual structure design abstracts the real objects into the information world to understand the relationship of each entity in the information world. The logical structure adds attribute constraints to the entities on the basis of the conceptual design. A good database design must meet the three paradigms of database design. The three paradigms are progressive layer by layer. At the same time, the three paradigms are also the core of relational database design. The first normal form (1NF) must satisfy the atomic properties of tuples, that is, tuples are the smallest data items that

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cannot be separated. On the basis of the first normal form, the second normal form (2NF) requires that each element can only depend on the primary key. The third normal form (3NF) is based on the second normal form, which requires that each non primary element cannot pass dependencies. In the process of obtaining data, the intelligent warehousing management system based on the Internet of things mainly relies on the form of RFID electronic tag and barcode scanning technology to obtain the information of relevant goods in warehousing activities. When the electronic tag number is obtained in the process of warehousing activities, the commodity information is read and stored in the database data table through conversion [29,30]. In the warehousing process, when the goods with electronic tags pass through the entrance with fixed RFID reader, the RFID reader will read the specific information of the goods. At this time, the warehousing order will obtain the corresponding information of each goods according to the number of each electronic tag. During the counting, the staff shall formulate the inventory list as required. During the counting, the staff shall use the handheld RFID to count, read and write the information in the electronic tag of the counted goods through the RFID reader for statistics, and the system will store the data obtained from the counting in the counting table of the database. In the process of inventory management, the electronic tag number of goods is also obtained through the handheld terminal RFID, so as to obtain the storage information inside and know which goods are in short inventory. At the same time, the insufficient information is stored in the inventory list data table. In the process of delivery, the staff first select the delivery goods according to the needs and produce the delivery list. When the goods pass the export and are detected by fixed RFID technology, the delivery information of each commodity is obtained by obtaining the electronic tag number of the commodity. On the basis of meeting the database design requirements, several main data tables designed based on the Internet of things intelligent warehouse management system are shown in Table 4.

Table 4 Company information(Company_ Info)

Column name	Data type	Can it be blank	Explanation	Database fields
Number	varchar	No	Primary key	CP ID
Type	varchar	No		CP_ Type
Name	varchar	No		CP Name
Region	varchar	No		CP Adress

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Contact number	varchar	No		CP Phone
Person in charge	varchar	No		CP Head
Remarks	varchar			CP Remar
Creation time	datetime	No		CP Time

Table 6 warehouse in and warehouse out operation sheet(Warehousing single header)

Column name	Data type	Can it be blank	Explanation	Database fields
Document number	Varchar	No	Primary key	WSH ID
Tag number	varchar	No		Label ID
Type	varchar	No		WSH_ Type
Shelf number	varchar	No		WSH_ Sh_ ID
Shelf area type	varchar	No		WSH_ S_ Typ
Warehouse type	varchar	No		WSH_Ware_Type
Execution status	varchar	No		WSH_ Exe_ Type

See Table 7 for the stock in and stock out operation list.

Table 7 Warehouse in and warehouse out operation sheet(Warehousing single)

Column name	Data type	Can it be blank	Explanation	Database fields
Document number	varchar	No	Primary key	WS_ ID
Tag code	varchar	No		Label ID
Pallet number	varchar	No		WS_ Tray_ ID
Item code	varchar	No		WS Good ID

The inventory information table is shown in Table 8.

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Table 8 Inventory information(Inventory information table)

Column name	Data type	Can it be blank	Explanation	Database fields
ID	varchar	No	Primary key	II ID
Shelf No	varchar	No		II_ Shelf ID
Item code	varchar	No		II_ Good_ ID
Source document	varchar	No		II_ Doc_ Sou
Pallet No	varchar	No		II_ Tray_ ID
Quantity	Int	No		11 Number
Company	varchar	No		II_ Company

The operation table of electronic label shelf is shown in Table 9.

Table 9 Operation table of electronic label shelf(Electronic label shelf operation table)

Column name	Data type	Can it be blank	Explanation	Database fields
Operation number	varchar	No	Primary key	EL ID
Description of goods	varchar	No		EL_ Good Name
Item code	varchar	No		EL Good ID
Operation source	varchar	No		EL_ Oper_ Sou

The intelligent warehouse management system based on the Internet of things technology binds the goods with electronic labels to the vehicle after the goods are loaded on the vehicle. The global positioning system (GPS) technology is combined with the global geographic information system (GIS) and sensor technology, so that the specific location and environmental information of the goods can be monitored during transportation. When the goods arrive at the warehouse center, the RFID technology is used to inspect the goods. The basic information of the goods identified by the RFID technology is matched with the original information sheet of the goods that needs to be warehoused. After reaching the standard, all the warehoused information will be stored in the electronic labels of each warehoused

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commodity to realize the whole process recording of all the goods information. For the goods that do not conform to the inspection, the reasons for the nonconformity will be given and prompted, and the staff will handle them according to the actual situation. After the goods are warehoused, the system obtains the basic information of the goods through the RFID radio frequency technology. The goods are warehoused through the intelligent warehouse division function of the intelligent warehouse management system. In the process of warehouse division, the system can manually root Select the goods storage warehouse according to actual needs or systematically select the storage location according to the optimization algorithm. The AGV trolley will obtain the basic information and storage information of the goods, and the AGV trolley will transport the goods to the designated storage location. Since the data is stored back from the system, the stacker receives the counter, phase and specific data of each device through RFID technology, transports the goods to the end, and completes the storage on site. Operational issues are the most important part of business. The products in the commodity are usually consumer-oriented. Strictly control the quality and quantity of products. If the goods in the product are returned to the company due to a problem, the company's reputation will decline. The outbound operation process is complex and cumbersome, which requires a lot of manpower and financial resources to perform, and is often very inefficient. The intelligent warehouse uses RFID to automatically check the outbound commodity information, and give prompt and warning for unqualified or incorrect commodities. For the goods that have been verified successfully, the quality and other basic information will be obtained for inspection, and the goods will not be delivered until the inspection results are obtained. In this process, the IoT-based intelligent warehouse management system inputs important information of the goods to be shipped before creating the shipment, and the intelligent management system checks and locates the related products and shipments. In this case, there is no need to check simple information such as cargo location. After selecting the express, check the important information such as the quantity and quality of the goods according to the delivery note to know whether the express meets the requirements. RFID radio frequency technology will obtain the information of the delivered goods. The information of the delivered goods that meet the delivery requirements will be modified and written into the electronic tag.

5 Conclusion

Firstly, this paper analyzes the bar code technology and the traditional logistics warehousing system, and makes a detailed analysis on the work efficiency, business process, inventory

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management, etc. through the analysis of its problems, it concludes the limitations of the traditional logistics warehousing management system, and paves the way for the new RFID system and its technology. After that, this paper introduces the RFID technology in detail, through the analysis of the technical principle, technical characteristics, structure and advantages, so as to complete the detailed and thorough analysis of the RFID technology. This paper then analyzes the application of RFID technology in logistics warehousing. Through a detailed analysis of the EPC system, RFID middleware, ons and PML server, GIS and GPS technology that constitute the RFID system, the specific architecture, software and hardware composition of the RFID system are described in detail. At the same time, through the process analysis, the warehousing management, in warehouse management and out of warehouse management in logistics warehousing management are analyzed in detail, and the functions and problems that can be realized in warehousing process management, in warehouse process management and out of warehouse process management are specifically studied in the form of flow charts and tables. The application of RFID technology is explored from the perspective of enterprise logistics warehousing operation execution. Finally, based on the above research, a new RFID system is proposed, and the advantages and practicability of the new RFID system are pointed out.

Data Availability Statement

No data were used to support this study.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

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Reference

[1] Prinsloo, J. G., & Malekian, R. (2016). Accurate vehicle location system using RFID, an internet of things approach. *Sensors*, *16*(6), 825. https://doi.org/10.3390/s16060825

[2] Al-Fuqaha, A., Guizani, M., Mohammadi, M., Aledhari, M., & Ayyash, M. (2015). Internet of Things: A survey on enabling technologies, protocols, and applications. *IEEE*

Power System Technology
ISSN:1000-3673
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Communications Surveys and Tutorials/IEEE Communications Surveys and Tutorials, *17*(4), 2347–2376. https://doi.org/10.1109/comst.2015.2444095

[3] Gansner, E. R., & North, S. (2000). An open graph visualization system and its applications to software engineering. *Software, Practice & Experience/Software, Practice and Experience*, *30*(11), 1203–1233. https://doi.org/10.1002/1097-024x(200009)30:11

[4] Pendry, J. B., Schurig, D., & Smith, D. R. (2006). Controlling electromagnetic fields. *Science*, *312*(5781), 1780–1782. https://doi.org/10.1126/science.1125907

[5] Stambaugh, R. F. (1983). Testing the CAPM with broader market indexes. *Journal of Banking & Finance*, *7*(1), 5–16. https://doi.org/10.1016/0378-4266(83)90052-3

[6] Berry, L. L. (2000). Cultivating service brand equity. *Journal of the Academy of Marketing Science*, *28*(1), 128–137. https://doi.org/10.1177/0092070300281012

[7] Hamilton, W. (1979). Tectonics of the Indonesian region. *U.S. Geological Survey Professional Paper*. https://doi.org/10.3133/pp1078

[8] Bolomey, J., Capdevila, S., Jofre, L., & Romeu, J. (2010). Electromagnetic modeling of RFID-Modulated Scattering Mechanism. Application to tag performance evaluation. *Proceedings of the IEEE*, *98*(9), 1555–1569. https://doi.org/10.1109/jproc.2010.2053332

[9] Whitehouse, K., Karlof, C., & Culler, D. (2007). A practical evaluation of radio signal strength for ranging-based localization. *Mobile Computing and Communications Review*, *11*(1), 41–52. https://doi.org/10.1145/1234822.1234829

[10] Valley, G. C., Sefler, G. A., & Shaw, T. J. (2012). Compressive sensing of sparse radio frequency signals using optical mixing. *Optics Letters/Optics Index*, *37*(22), 4675. https://doi.org/10.1364/ol.37.004675

[11] Tkáč, M., & Mésároš, P. (2019). Utilizing drone technology in the civil engineering. *Selected Scientific Papers*, *14*(1), 27–37. https://doi.org/10.1515/sspjce-2019-0003

[12] Kouba, N. E. Y., Menaa, M., Hasni, M., & Boudour, M. (2016). LFC enhancement concerning large wind power integration using new optimised PID controller and RFBs. *IET Generation, Transmission & Distribution*, *10*(16), 4065–4077. https://doi.org/10.1049/iet-gtd.2016.0385

[13] Gramacy, R. B., & Lee, H. K. H. (2008). Bayesian Treed Gaussian process models with an application to computer modeling. *Journal of the American Statistical Association*, *103*(483), 1119–1130. https://doi.org/10.1198/016214508000000689

[14] Williamson, J. G. (1965). Regional Inequality and the Process of National Development: A Description of the Patterns. *Economic Development and Cultural Change/Economic*

Power System Technology
ISSN:1000-3673
Received: 16-01-2024 Revised: 12-02-2024 Accepted: 07-03-2024

Development and Cultural Change (University of Chicago. Online), *13*, 1–84. https://doi.org/10.1086/450136

[15] Mito, T., Sagara, A., Imagawa, S., Yamada, S., Takahata, K., Yanagi, N., Chikaraishi, H., Maekawa, R., Iwamoto, A., Hamaguchi, S., Sato, M., Noda, N., Yamauchi, K., Komori, A., & Motojima, O. (2006). Applied superconductivity and cryogenic research activities in NIFS. *Fusion Engineering and Design*, *81*(20–22), 2389–2400. https://doi.org/10.1016/j.fusengdes.2006.07.086

[16] Balakrishnan, N., Rajendran, A., & Ajay, P. (2022). Deep embedded median clustering for routing misbehaviour and attacks detection in ad-hoc networks. *Ad Hoc Networks*, *126*, 102757. https://doi.org/10.1016/j.adhoc.2021.102757

[17] Mohamed, A. M., & Saad, S. M. (2016). Development of risk assessment model for equipment within the petroleum industry. *IFAC-PapersOnLine*, *49*(28), 37–42. https://doi.org/10.1016/j.ifacol.2016.11.007

[18] Minaee, M., Elahi, S., Majidpour, M., & Manteghi, M. (2021). Lessons learned from an unsuccessful "catching-up" in the automobile industry of Iran. *Technology in Society*, *66*, 101595. https://doi.org/10.1016/j.techsoc.2021.101595

[19] Dubourg, V., Sudret, B., & Bourinet, J. (2011). Reliability-based design optimization using kriging surrogates and subset simulation. *Structural and Multidisciplinary Optimization*, *44*(5), 673–690. https://doi.org/10.1007/s00158-011-0653-8

[20] Basheer, I. A., & Hajmeer, M. N. (2000). Artificial neural networks: fundamentals, computing, design, and application. *Journal of Microbiological Methods*, *43*(1), 3–31. https://doi.org/10.1016/s0167-7012(00)00201-3

[21] Cheremisinoff, N. P. (2002). Industrial Air Pollution Sources and Prevention. In *Elsevier eBooks* (pp. 53–147). https://doi.org/10.1016/b978-075067499-7/50003-1

[22] Williams, A. (2007). Product service systems in the automobile industry: contribution to system innovation? *Journal of Cleaner Production*, *15*(11–12), 1093–1103. https://doi.org/10.1016/j.jclepro.2006.05.034

[23] Simamora, L. S. P., & Gunawan, F. (2001). Indonesia Electronic Library Design Plan for supporting a Distance Learning Environment. *Journal of Library Administration*, *32*(1–2), 361–369. https://doi.org/10.1300/j111v32n01_11

[24] Pauwels, K., Silva-Risso, J., Srinivasan, S., & Hanssens, D. M. (2004). New products, sales promotions, and firm value: the case of the automobile industry. *Journal of Marketing*, *68*(4), 142–156. https://doi.org/10.1509/jmkg.68.4.142.42724

Power System Technology
ISSN:1000-3673
Received: 16-01-2024 Revised: 12-02-2024 Accepted: 07-03-2024

[25] Denton, T. (2013). Automobile electrical and electronic systems. In *Routledge eBooks*. https://doi.org/10.4324/9780080969435

[26] Kurnia, S., Karnali, R. J., & Rahim, M. M. (2015). A qualitative study of business-to-business electronic commerce adoption within the Indonesian grocery industry: A multi-theory perspective. *Information & Management*, *52*(4), 518–536. https://doi.org/10.1016/j.im.2015.03.003

[27] Bongard, J., & Lipson, H. (2007). Automated reverse engineering of nonlinear dynamical systems. *Proceedings of the National Academy of Sciences of the United States of America*, *104*(24), 9943–9948. https://doi.org/10.1073/pnas.0609476104

[28] Veikkolainen, T., Pesonen, L. J., & Evans, D. A. (2014). PALEOMAGIA: A PHP/MYSQL database of the Precambrian paleomagnetic data. *Studia Geophysica Et Geodaetica*, *58*(3), 425–441. https://doi.org/10.1007/s11200-013-0382-0

[29] Christopher, M., & Peck, H. (2004). Building the resilient supply chain. *International Journal of Logistics Management/˜ the œInternational Journal of Logistics Management*, *15*(2), 1–14. https://doi.org/10.1108/09574090410700275

[30] Shorten, C., & Khoshgoftaar, T. M. (2019). A survey on Image Data Augmentation for Deep Learning. *Journal of Big Data*, *6*(1). https://doi.org/10.1186/s40537-019-0197-0