# Warehouse Management Information System Technology Review

Hua Chen [1,3] and Maria Amelia E. Damian [2]
[1]Graduate School, University of the East, Manila, Philippines
[2]Faculty College of Engineering, University of the East, Manila, Philippines
[3]Jiangsu Shipping College, Jiangsu,China
mariaamelia.damian@ue.edu.ph

***Abstract*—With the rapid development of information technology, warehouse management information systems are playing an increasingly important role in modern logistics management. This paper first elaborates on the importance of warehouse management information systems and the impact of technological development on warehouse management, and then reviews the development process of warehouse management information systems. Next, it focuses on introducing the application of key technologies such as barcode technology, RFID technology, UWB high-precision positioning technology, wireless network communication technology, cloud computing technology, and big data analysis technology in warehouse management. In addition, this paper also analyzes the current problems faced by warehouse management information systems and discusses the application prospects of emerging technologies such as artificial intelligence, Internet of Things, blockchain, automation, and robotics in warehouse management. Finally, it summarizes the main findings of the review and proposes insights and suggestions for the development of warehouse management information systems and future research directions.**

***Index Terms*—Warehouse management system; RFID; UWB; Artificial intelligence; Internet of Things**

## I. Introduction

### *A. The Importance of Warehouse Management Information Systems*

Warehouses are important nodes in the supply chain, and their management level directly affects the operational efficiency and economic benefits of enterprises. Traditional warehouse management mainly relies on manual operations, which are inefficient and error-prone. With the development of information technology, warehouse management information systems have emerged, realizing the informatization, automation, and intelligence of warehouse management through computer technology, automatic identification technology, communication technology, etc., greatly improving warehouse management efficiency and reducing labor costs and error rates [1].

Research shows that after implementing a warehouse management information system, enterprises' inventory turnover rate increased by an average of 30%, order processing efficiency increased by 25%, and picking and inventory efficiency increased by more than 50% [2]. It can be seen that the warehouse management information system has become one of the key factors for modern logistics enterprises to enhance their competitiveness.

### *B. The Impact of Technological Development on Warehouse Management*

The rapid development of information technology has brought profound changes to warehouse management. On the one hand, the application of new automatic identification and data collection technologies such as RFID, sensors, and mobile terminals has realized real-time visual management of warehouse operations and improved the level of refined warehouse management [3]. On the other hand, the development of technologies such as the Internet, Internet of Things, cloud computing, and big data has made it possible to integrate, share, and analyze massive warehouse data, laying the foundation for intelligent decision-making and optimization scheduling of warehouses [4].

In addition, the application of emerging technologies such as artificial intelligence, blockchain, automation, and robotics in warehouse management has also received increasing attention. Artificial intelligence technology can be used for demand forecasting, inventory optimization, intelligent sorting, etc., to improve the level of warehouse management intelligence [5]. Blockchain technology is expected to solve problems such as information asymmetry and fraud in various links of the supply chain [6]. The application of automation and robotics can greatly reduce labor costs and improve operational efficiency and accuracy [7].

### *C. Purpose and Structure of the Review*

Given the importance of warehouse management information systems and the impact of technological development on them, systematically sorting out the research progress in related fields is of great significance for guiding the construction and application of warehouse management information systems. This paper reviews the development process, key technologies and applications, existing problems, and future development trends of warehouse management information systems, with a view to providing reference for relevant research and practice.

## II. Development Process of Warehouse Management Information Systems

Warehouse management information systems have experienced a development process from manual management to computerization, networking, and intelligence.



ISSN:3006-2985(Print)
ISSN:3006-9297(Online)

### A. The Early Stage of Manual Management

Before the 1980s, warehouse management mainly relied on manual operations, and information was recorded and transmitted through paper documents, with low management efficiency and easy errors [8]. During this period, the level of warehouse management mainly depended on the experience and ability of managers, and lacked standardized and normalized management processes.

### B. The Stage of Computerized Management

In the 1980s, computer technology began to be applied in the field of warehouse management. Some enterprises developed simple warehouse management software to use computers for information input, storage, and processing, improving information management efficiency [9]. Barcode technology also began to be applied in the warehouse field, but it was mainly limited to the identification of materials and products.

The warehouse management systems in this period had relatively single functions, mainly including basic functions such as warehousing, ex-warehousing, and inventory management, and there was a lack of integration and data sharing between systems [10]. With the growth of business volume, a single warehouse management system could no longer meet the management needs of enterprises.

### C. The Stage of Networked and Intelligent Management

Entering the 21st century, the popularization of Internet technology and the development of emerging technologies such as RFID and mobile computing have promoted the development of warehouse management towards networking and intelligence. Some leading enterprises began to build Internet-based warehouse management systems, realizing multi-warehouse collaboration and integrated supply chain management [11].

RFID technology has been widely used in warehouse management, realizing real-time control and visual management of warehouse operations through the whole-process tracking of items [12]. More and more intelligent algorithms and analysis models are being applied in fields such as demand forecasting, inventory optimization, and intelligent sorting, improving the level of warehouse management intelligence [13].

Table I shows a comparison of the characteristics of warehouse management information systems at different stages of development. It can be seen that the warehouse management information system has experienced a development process from scratch, from simple to complex. The continuous emergence of new information technologies has promoted the development of warehouse management towards a more intelligent and refined direction. In the future, the application of technologies such as the Internet of Things and artificial intelligence in warehouse management will be further deepened, promoting the transformation of warehouse management models.

TABLE I
COMPARISON OF CHARACTERISTICS OF WAREHOUSE MANAGEMENT INFORMATION SYSTEMS AT DIFFERENT STAGES OF DEVELOPMENT

| Development Stage | Management Mode | Applied Technology | System Function | Data Application |
|---|---|---|---|---|
| Manual Management | Manual Operation | Paper Documents | None | None |
| Computerized | Computer Management | Barcode | Single Function | Partial Application |
| Networked | Multi-Warehouse Collaboration | RFID, Mobile Computing | Integration | Data Sharing |
| Intelligent | Intelligent Decision-Making | Internet of Things, Artificial Intelligence | Intelligent Optimization | Big Data Analysis |

## III. KEY TECHNOLOGIES AND THEIR APPLICATIONS

### A. Barcode Technology

Barcode technology is an automatic identification technology that was applied to warehouse management earlier, which identifies and tracks items through barcode labels. Compared with manual input, barcode technology has the advantages of fast input speed, high accuracy, and low cost [14]. In warehouse management, barcode technology is mainly used in links such as material and product identification, storage location management, and inventory.

However, barcode technology also has some limitations: barcode capacity is limited and can only store a small amount of information; barcodes are easily polluted and damaged, and the read rate is not high; barcodes cannot realize long-distance batch reading, etc. [15]. Therefore, barcode technology is more suitable for scenarios with high requirements for identification speed and accuracy, but low requirements for label cost and data capacity.

### B. Radio Frequency Identification (RFID) Technology

RFID technology uses radio frequency signals for non-contact identification and data transmission of items, with the advantages of long reading distance, strong penetration, large data capacity, and rewritability, making up for the shortcomings of barcode technology [16]. The application of RFID technology in warehouse management includes:

(1) Item tracking: By attaching RFID tags to items and using the deployed RFID readers to realize real-time positioning and tracking of items, improving the level of visual management of warehouse operations [17].

(2) Automatic inventory: Using RFID handheld terminals or antenna arrays for batch inventory of inventory, improving inventory efficiency and accuracy, and reducing manual errors [18].

(3) Intelligent sorting: Identifying items through RFID technology and realizing automatic sorting of items in combination with sorting algorithms, improving sorting efficiency [19].

(4) Anti-theft and error prevention: Using RFID electronic tags to identify high-value items, automatically checking them

during storage and ex-warehousing, reducing theft and delivery errors [20].

Figure 1 shows an RFID-based warehouse management system architecture. The system attaches RFID tags to items, and uses devices such as RFID handheld terminals and RFID readers to collect information from various links of warehouse operations, and combines with upper-layer application software to realize real-time tracking and management of items.

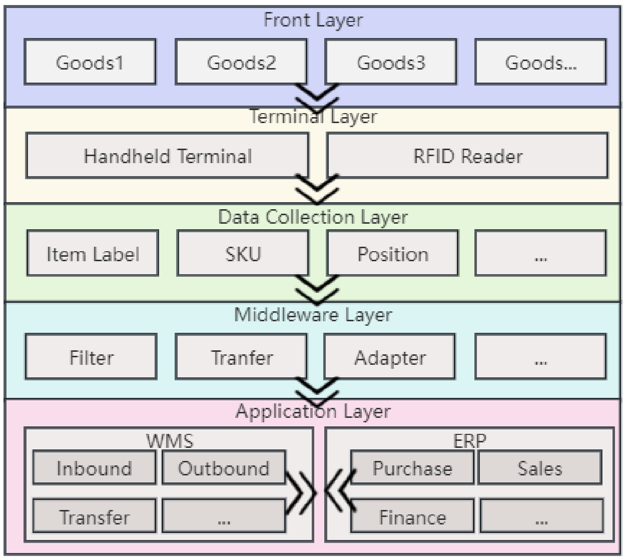


Fig. 1. RFID-Based Warehouse Management System Architecture

Although RFID technology has many advantages, it still faces some challenges in practical applications: the cost of RFID tags is relatively high, and the economics of large-scale applications need to be further improved; the standardization of RFID technology is insufficient, and the interoperability between equipment is poor; RFID signals are easily affected by the environment and the reading performance decreases in special environments such as metals and liquids [21]. These problems have constrained the further promotion and application of RFID technology in the warehousing field to a certain extent.

### C. UWB High-Precision Positioning Technology

UWB (Ultra-Wide Band) is an emerging wireless communication and positioning technology that realizes high-precision positioning and communication by emitting nanosecond-level ultra-wideband pulses [22]. UWB technology has the advantages of strong penetration, strong anti-interference ability, and high security, which is very suitable for accurate positioning in indoor environments.

In warehouse management, UWB technology can be used in storage location management, cargo positioning, automated equipment scheduling, etc. By installing UWB tags on objects such as shelves, forklifts, and AGV carts, and using UWB base stations to locate them, real-time inventory and dynamic management of inventory can be realized, improving the level of refined warehouse management [23]. The positioning accuracy of UWB can reach the centimeter level, which can meet the high-precision requirements of warehouse operations.

Figure 2 shows an intelligent warehouse operation scheduling system based on UWB. The system installs UWB tags on various logistics equipment, uses UWB base stations deployed in the warehouse to locate them in real time, and uploads the location information to the central control system. The control system schedules equipment such as forklifts and AGV carts in real time according to the storage and ex-warehousing needs of goods, and the distribution of cargo locations and equipment locations, instructing them to perform loading, unloading, and handling operation tasks [24].

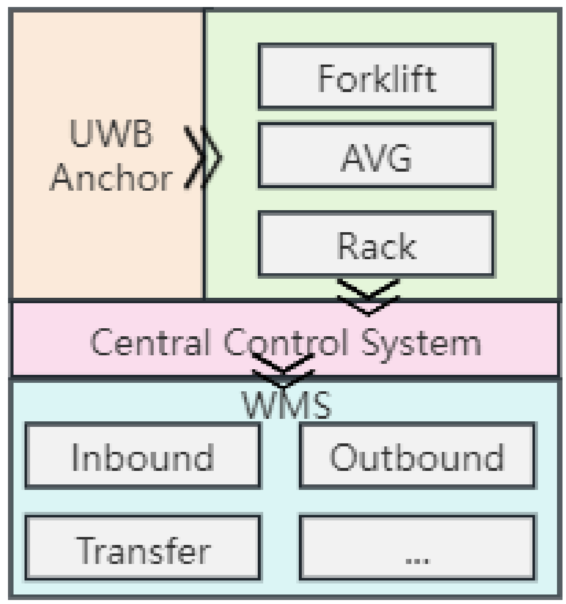


Fig. 2. Intelligent Warehouse Operation Scheduling System Based on UWB

Compared with other indoor positioning technologies (such as RFID and WiFi), UWB technology has the advantages of high precision, low power consumption, and strong real-time performance [25]. However, the large-scale application of UWB technology still faces challenges such as standardization and cost [26]. In addition, research on UWB positioning algorithms needs to be further deepened to improve the accuracy and stability of positioning.

### D. Wireless Network Communication Technology

Wireless communication technology is the basis for realizing the networking and data transmission of warehousing equipment. At present, the main wireless communication technologies applied in the warehousing field include WIFI, ZigBee, Bluetooth, LoRa, etc. [27].

WIFI technology adopts the IEEE 802.11 protocol and has the characteristics of high transmission rate and wide coverage, which is suitable for application scenarios with large data volume and high real-time requirements, such as video surveillance and voice picking in unattended warehouses [28]. However, WIFI technology has higher power consumption and is affected by co-channel interference.

ZigBee technology is based on the IEEE 802.15.4 protocol and has the advantages of low power consumption, low cost, and flexible networking, which is very suitable for application scenarios that are sensitive to power consumption and cost, such as warehouse environment monitoring and shelf management [29]. However, ZigBee's data transmission rate and coverage are limited.

Bluetooth technology has the characteristics of low power consumption, low cost, and plug and play, and is mainly used for short-distance communication between warehousing equipment, such as data transmission between barcode scanners and PDAs [30].

LoRa technology adopts spread spectrum modulation technology and has the advantages of wide coverage, strong penetration, and low power consumption, which is suitable for scenarios that are sensitive to power consumption and do not require high-speed transmission, such as remote monitoring of warehousing facilities [31].

In practical applications, it is necessary to comprehensively consider factors such as the warehousing environment and application requirements to select appropriate wireless communication technologies. At the same time, it is also necessary to ensure the interconnection and interoperability of different wireless networks to realize the integrated application of multiple networks [32]. Figure 3 shows a network architecture design of a warehousing Internet of Things system, which comprehensively utilizes a variety of wireless communication technologies to realize the interconnection and management of warehousing equipment and goods.

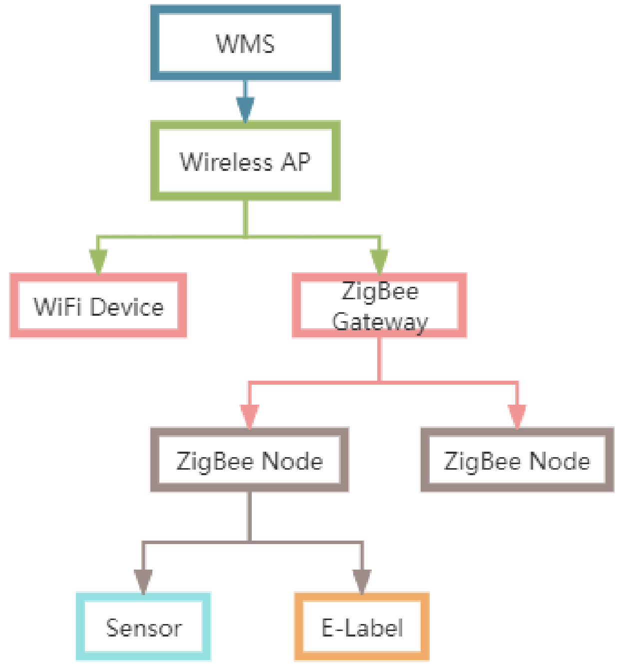


Fig. 3. Network Architecture Design of Warehousing Internet of Things System

In addition, the cloud computing platform can also provide data analysis and decision support for intelligent warehousing equipment. The massive data generated by intelligent devices can be uploaded to the cloud for storage and analysis, using machine learning algorithms to optimize warehousing decisions, such as demand forecasting and inventory optimization [36]. Figure 4 shows an intelligent warehouse management system architecture based on cloud computing, which uniformly manages data from different warehouses and provides intelligent analysis services.

### *E. Cloud Computing Technology*

Cloud computing is a model that provides configurable computing resources (such as networks, servers, storage, applications, and services) on demand, and provides fast and flexible IT resource supply and services through the Internet [33]. Cloud computing has the characteristics of high reliability, high scalability, and on-demand service, which is very suitable for the construction and deployment of warehouse management information systems.

Deploying the warehouse management system in the cloud can significantly reduce the investment in IT infrastructure of enterprises and improve the scalability and reliability of the system. At the same time, the elastic computing and massive storage resources provided by the cloud platform can meet the needs of warehouse big data applications [34]. Some cloud service providers also provide SaaS warehousing management solutions, which enterprises can rent on demand to quickly build warehouse management information systems [35].

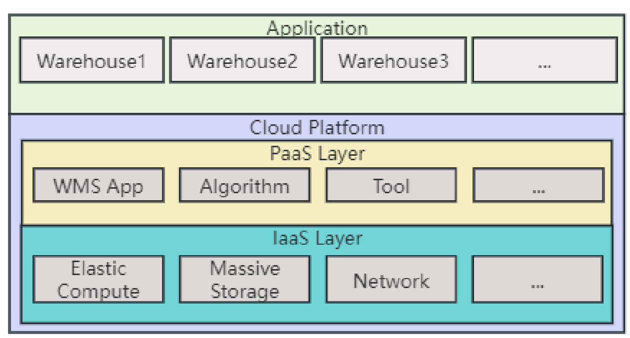


Fig. 4. Intelligent Warehouse Management System Architecture Based on Cloud Computing

### *F. Big Data Analysis Technology*

With the application of Internet of Things technology in the warehousing field, warehouse management systems have produced massive multi-source and heterogeneous data, which contains huge value. Using big data analysis technology, valuable information can be mined from warehousing data to optimize warehousing management decisions [37].

Common big data analysis methods include data mining, machine learning, and visual analysis. Data mining technology can be used to discover association rules, clustering patterns, etc. in warehousing data, such as analyzing the associated storage rules of goods and the clustering division of storage locations [38]. Machine learning methods such as support vector machines and random forests can be used for demand forecasting and inventory optimization [38]. Visual analysis methods such as dashboards and heat maps can intuitively present the operating status of warehousing and assist management decision-making [40].

Figure 5 shows a big data-driven warehousing optimization process. The system collects multi-source and heterogeneous warehousing data, stores it in a big data platform after data integration and preprocessing, and then uses data mining, machine learning and other methods for data analysis and knowledge discovery, and uses the analysis results to guide warehousing optimization, forming a closed-loop feedback [41].

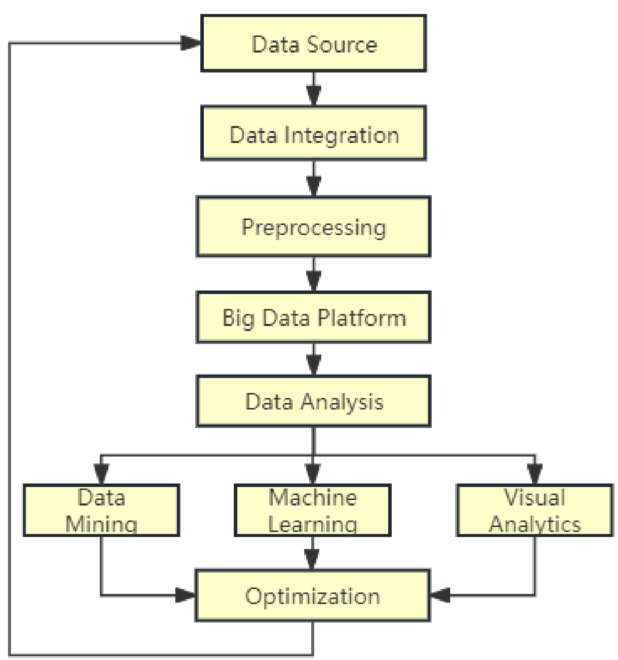


Fig. 5. Big Data-Driven Warehousing Optimization Process

Big data analysis provides new ideas for warehousing management decision-making, but it also faces some challenges: warehousing data types are numerous, and data quality varies, requiring data cleaning and fusion; there is a lack of big data analysis tools specifically for warehousing scenarios, and general tools cannot meet actual needs; there is a shortage of compound talents with knowledge of the warehousing field and data analysis skills [42]. These problems urgently need the joint efforts of academia and industry.

## IV. Current Status and Problems of Warehouse Management Information Systems

### A. System Integration and Interoperability Issues

At present, enterprise warehousing information systems usually include multiple heterogeneous subsystems such as WMS, ERP, MES, and TMS. These systems lack unified standards in data formats, interface protocols, etc., making it difficult to integrate and interoperate between systems [43]. The efficiency of data transmission and conversion between systems is low, making it difficult to achieve end-to-end visual management, which affects the efficiency of warehousing operations.

Therefore, it is urgently necessary to strengthen the standardization work of warehousing information systems, formulate unified data format and interface specification standards, and promote the interconnection and interoperability of warehousing information systems [44]. At the same time, it is also necessary to adopt service-oriented architecture (SOA), enterprise service bus (ESB) and other technologies to build a flexible and scalable system integration architecture [45].

### B. Data Security and Privacy Protection

Warehousing information systems gather a large amount of sensitive data such as cargo flow data and customer information. If data leakage occurs, it will cause major losses to enterprises. With the migration of warehousing information systems to the cloud, data security issues have become more prominent [46]. For cloud-based systems, measures such as identity authentication, access control, and data encryption need to be taken to ensure the confidentiality, integrity, and availability of data [47].

In addition, some warehousing data may involve personal privacy, such as the recipient information in express logistics information. GDPR and other privacy protection regulations have put forward strict requirements for the collection, storage, and use of personal data [48]. Warehousing information systems need to follow the principle of minimum sufficiency and adopt technologies such as data desensitization to protect personal privacy to the greatest extent.

### C. Cost-Benefit Analysis

While advanced warehousing information technology improves warehousing management efficiency, it also brings significant cost investment. The procurement cost of RFID electronic tags and intelligent sorting equipment is high [49], and the development, integration, and operation and maintenance of the system also require a lot of funds [50]. Therefore, it is necessary to carry out cost-benefit analysis of warehousing informatization, weigh the technical investment and management benefits, and select the optimal system construction plan.

Cost-benefit analysis needs to weigh the input and output of warehousing informatization from a strategic perspective. On the one hand, it is necessary to consider the long-term value of warehousing informatization for improving customer service levels and enhancing market competitiveness; on the other hand, it is necessary to prevent blindly following the trend and avoid the waste of resources caused by a rush [51]. At the same time, it is also necessary to continuously carry out informatization performance evaluation and dynamically optimize and adjust the system construction.

### D. Personnel Training and Adaptability

Warehousing informatization is a gradual process that requires enterprise employees to change their concepts and improve their information technology application capabilities. Most traditional warehousing operators have a low level of education and lack the necessary informatization skills [52], making it difficult to adapt to the requirements of digital transformation. Therefore, enterprises need to increase education and training efforts, and improve employees' informatization literacy through internal training and external introduction of talents [53].

At the same time, enterprises also need to optimize business processes and organically combine automated and informatized equipment with manual operations to give play to the advantages of human-machine collaboration [54]. When introducing new technologies and new equipment, it is necessary to fully consider the acceptance and adaptability of operators, and adopt a gradual strategy when necessary to reduce employees' resistance.

## V. Future Development Trends and Prospects

### A. Application of Artificial Intelligence in Warehouse Management

Artificial intelligence technology empowers warehousing management, making the level of intelligence continue to improve. Using computer vision, natural language understanding and other technologies, intelligent monitoring and instruction recognition of warehousing operations can be realized, improving operation efficiency and accuracy [55]. Machine learning algorithms can be applied to decision optimization scenarios such as demand forecasting and inventory optimization to minimize inventory costs [56].

In addition, artificial intelligence can also be combined with automated equipment to realize intelligent handling, sorting and other operations. Intelligent AGV carts can autonomously complete cargo handling according to dynamic scheduling instructions; intelligent sorting robots can automatically complete commodity sorting through visual recognition, mechanical arm operation and other technologies [57], integrating multiple artificial intelligence technologies to realize full-process automation of warehousing operations.

Of course, the application of artificial intelligence in the warehousing field is still in its infancy, and there are still many challenges: the lack of large-scale warehousing operation data accumulation makes model training difficult; the warehousing scenarios are complex and changeable, and the robustness and generalization of algorithms need to be improved; the realization of interaction is difficult, and the interpretability is insufficient [58]. In the future, it will be necessary to focus on tackling key problems in scenario adaptation and human-machine collaboration, and continuously expand the breadth and depth of the application of artificial intelligence in warehousing management.

### B. Integrated Application of Internet of Things Technology

With the rapid development of Internet of Things technologies such as RFID and sensors, warehousing information systems have entered the stage of Internet of Things from the stage of simple digitization and networking. In the Internet of Things architecture, intelligent devices such as smart shelves, AGV carts, and drones are interconnected through the network, automatically perceiving the warehousing environment and operation status, and uploading data to the management system in real time, forming a real-time presentation of information such as cargo status and inventory level, providing intuitive basis for warehousing management [59], [60].

In the future, the application of new-generation communication technologies such as 5G and NB-IoT will make warehousing Internet of Things communication faster and more stable, and technologies such as edge computing will also enable intelligent devices to have local data processing capabilities, reducing the burden on the network [61]. Emerging technologies such as digital twins can also realize virtual mapping of warehousing systems, optimizing system testing and predictive decision-making [62].

At the same time, based on the Internet of Things and combined with enabling technologies such as big data and artificial intelligence, intelligent perception, analysis, optimization and control of the entire warehousing business chain can be realized, and a new generation of smart warehousing system with self-adaptation, self-organization, and self-optimization can be constructed [63]. Figure 6 shows an Internet of Things architecture design oriented to smart warehousing, which consists of a perception layer, network layer, platform layer, and application layer, integrating various Internet of Things and intelligent technologies to realize overall intelligent optimization of warehousing management.

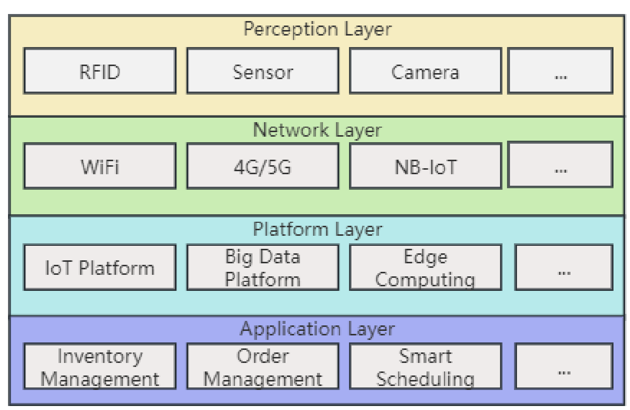


Fig. 6. Internet of Things Architecture Design Oriented to Smart Warehousing

The Internet of Things is a key infrastructure for realizing smart warehousing, but its large-scale application still faces many challenges: the heterogeneity of Internet of Things devices leads to poor interoperability, and there is a lack of unified access standards; massive Internet of Things data poses severe challenges to communication networks and computing platforms; Internet of Things security issues are prominent, and end-to-end security protection mechanisms are required at various levels such as the perception layer, network layer, and application layer [64]. In the future, it will be necessary to work together to accelerate the development of Internet of Things platforms and standards, and promote the deep integration of Internet of Things technology with the warehousing industry application environment.

### C. Potential Value of Blockchain Technology

Blockchain, as a decentralized and tamper-proof distributed ledger technology, can be used to reshape the trust system of the warehousing supply chain. The warehousing supply chain involves multiple parties such as suppliers, manufacturers, warehousers, and carriers, making business collaboration and information sharing difficult, and prone to problems such as information asymmetry and fraud [65]. Using blockchain technology, the identity and cargo flow information of various entities can be stored on the chain, ensuring the authenticity and traceability of information, and improving the collaboration efficiency of various parties in the supply chain [66].

In addition, the combination of blockchain and smart contract technology can realize the automation of warehousing business activities, such as triggering inbound quality inspection and outbound settlement, reducing manual intervention and improving business efficiency [67]. The combination of blockchain and Internet of Things technology can realize real-time traceability of the entire life cycle of goods, enhancing the visual management level of the supply chain [68].

Although blockchain technology has great potential, its application in the warehousing field is still in the exploratory stage. At present, the performance of blockchain platforms is insufficient and it is difficult to support large-scale and high-concurrency business scenarios; it is difficult to transform complex warehousing business processes into blockchain, and there are many practical challenges in the whole process of on-chain; there is a lack of mature blockchain solutions and application cases, and enterprises have low willingness to participate [69]. In the future, it will be necessary to strengthen the research on key technologies such as blockchain core algorithms, privacy protection, and cross-chain mechanisms, vigorously promote blockchain innovation application pilot projects, and explore the construction of a trusted warehousing ecosystem based on blockchain.

### D. Deepening Application of Automation and Robotics Technology

Automated three-dimensional warehouses, AGV carts, sorting robots and other automated equipment have been initially applied in modern warehousing systems, significantly improving the efficiency of warehousing operations. In the future, the application of automation and robotics technology in the warehousing field will continue to deepen, developing from single equipment and single operation links to full-process and systematic applications.

Multi-layer shuttle vehicles, high-density storage and other advanced technologies will greatly improve the space utilization of three-dimensional warehouses [70]; laser SLAM navigation and visual obstacle avoidance technologies will make AGV cart operations more flexible and efficient [71]; soft robots and bionic manipulators and other new robots will break through the applicability limitations of traditional rigid robots, realizing intelligent sorting operations of complex items [72].

In addition, the deep integration of automation and robotics equipment with emerging technologies such as the Internet of Things, big data, and artificial intelligence will further expand the application scenarios and realization forms of intelligent warehousing. In the future, warehousing operations can achieve full-process automation and unmanned operation, requiring only a small number of personnel for remote monitoring, greatly reducing labor costs and improving management efficiency [73]. At the same time, the massive equipment data and operation data also lay the data foundation for intelligent applications such as intelligent scheduling optimization and predictive maintenance.

Of course, the application of automation and robotics technology also faces challenges such as high cost, difficult maintenance, and poor scenario adaptability. The deployment of automated systems requires large-scale upfront investment, and the economics need to be further improved; the diagnosis and maintenance of robot equipment failures are highly professional, and there is a shortage of talents; there is a large demand for personalized and small-batch warehousing operations, and the development of general-purpose intelligent equipment lags behind [74]. In the future, it will be necessary to tackle the localization of core components of robots, accelerate the construction of a standardization system, and promote the deep adaptation of automation and robotics technology to the application environment of the warehousing industry, and improve the level of industrialization.

## VI. Conclusion

This paper reviews the development process, key technologies and their application status of warehouse management information systems, analyzes the problems existing in current warehouse management information systems such as integration and interoperability, security and privacy, and economics, and looks forward to the application prospects and development directions of emerging technologies such as artificial intelligence, Internet of Things, blockchain, automation and robotics in smart warehousing.

Overall, modern warehousing management has developed from simple digital management to the stage of networking and intelligence, showing new characteristics of systematization, data-driven, and intelligent perception. The rapid development of new-generation information technology has greatly expanded the optimization space of warehousing management, and is expected to lead the industry transformation in terms of efficiency improvement, cost reduction, user services, and innovation models. However, restricted by bottlenecks such as standards and specifications, security and privacy, and comprehensive integration, the large-scale application of new technologies still faces many challenges, and it is urgently necessary to make overall efforts in top-level design, key technologies, and industrial ecology to accelerate the penetration and empowerment of technological innovation achievements in the warehousing field.

In the future, the construction of warehousing management information systems should adhere to the development path of demand-driven and technology-enabled, closely focusing on the goal of improving quality and efficiency, focusing on the application of new technologies such as the Internet of Things and artificial intelligence, and accelerating the construction of a modern warehousing management system that is intelligent, networked, and collaborative. At the same time, it is necessary to pay attention to the integration of technological innovation, management innovation, and business innovation, optimize business processes in the process of intelligent transformation, innovate service models, and realize the coordinated improvement of management, technology, and business.

In addition, warehousing enterprises should also strengthen industry-university-research cooperation with universities and scientific research institutions, and establish a sound talent training and technological innovation mechanism. Increase the training and introduction of highly skilled talents to provide a solid talent guarantee for the landing and application of new technologies; carry out continuous collaborative innovation in key areas to accelerate the research and development of core technologies and their transformation and application, providing a source of power for the development of smart warehousing.

In summary, the intelligent and networked transformation of warehousing management is an inevitable trend, and the application of emerging technologies is reshaping the form of the warehousing industry. Grasping the wave of technological revolution and deepening the reform of systems and mechanisms, China's warehousing industry will surely achieve leapfrog development and contribute greater strength to the construction of a modern circulation system and serving the high-quality development of the economy.

## REFERENCES


[1] X. Yan, "Design and Implementation of Warehouse Management System Supporting Storage Location Optimization Strategy," M.S. thesis, Beijing University of Posts and Telecommunications, Beijing, China, 2023.

[2] C. Liu, "Research on Intelligent Warehouse Management Evaluation of A Company," M.S. thesis, Dalian Maritime University, Dalian, China, 2023.

[3] Y. Song, "Research on Finished Product Warehouse Management Strategy of JSXN Company," M.S. thesis, Hebei University, Baoding, China, 2023.

[4] H. Yang, "Research on Label Quality Management Improvement of Dchuang Technology Company," M.S. thesis, Lanzhou University, Lanzhou, China, 2023.

[5] S. Jiang and S. Fang, "Review on Energy Efficiency Management of Microgrid in Logistics Center Oriented to Dual Carbon Goals," Journal of Shanghai Jiao Tong University, vol. 57, no. 7, pp. 769-780, Jul. 2023.

[6] D. Cheng, "Research on Warehouse Management Optimization of L Company Based on Lean Management," M.S. thesis, East China Normal University, Shanghai, China, 2022.

[7] Y. Zhang, "Research on Inventory Management of Pingyuan Daba Cement Co., Ltd. Based on Business-Finance Integration," M.S. thesis, Shandong Agricultural University, Tai'an, China, 2022.

[8] S. Fang, "Research on Express Box Ordering Strategy of A Company," M.S. thesis, Beijing Jiaotong University, Beijing, China, 2022.

[9] Y. Niu, "Research on Financial Process Reengineering of Small and Micro Enterprises," M.S. thesis, Shandong University, Jinan, China, 2022.

[10] J. Zhou, "Research on Inventory Management Optimization of H Company Based on VMI Model," M.S. thesis, East China Normal University, Shanghai, China, 2021.

[11] Q. Meng, "Analysis and Optimization Research on Warehouse Management of WCompany," M.S. thesis, Tianjin University of Finance and Economics, Tianjin, China, 2021.

[12] Z. Jin, "Research on Inventory Management of NY Civil Explosive Company," M.S. thesis, Dalian University of Technology, Dalian, China, 2021.

[13] H. Yang, "Research on the Improvement of VMI Mode of S Company," M.S. thesis, Yangzhou University, Yangzhou, China, 2021.

[14] W. Cheng, "Research on Intelligent Warehouse Management of B Logistics Company," M.S. thesis, Shanghai International Studies University, Shanghai, China, 2021.

[15] Z. Zhang, "Research on the Improvement of Cold Chain Logistics Management of BC Company," M.S. thesis, Soochow University, Suzhou, China, 2020.

[16] H. Wu, "Case Study on Internal Control of Inventory of W Juice Company," M.S. thesis, Jilin University of Finance and Economics, Changchun, China, 2020.

[17] F. Peng, "Research on Optimization of Operation Process of Finished Product Warehouse of V Factory," M.S. thesis, Shenzhen University, Shenzhen, China, 2019.

[18] H. Ma, "Case Study on Internal Control of Inventory of G Juice Company," M.S. thesis, Chinese Academy of Fiscal Sciences, Beijing, China, 2019.

[19] W. Wang, "Research on Intelligent Warehouse Management of V Company," M.S. thesis, Capital University of Economics and Business, Beijing, China, 2019.

[20] J. Zhao, "Research on Optimization of Inventory Control of XD Aluminum Company," M.S. thesis, Shanghai International Studies University, Shanghai, China, 2019.

[21] F. Deng, "Research on Inventory Management Improvement of Changsha Lianyuan Company," M.S. thesis, Hunan University, Changsha, China, 2019.

[22] M. Li, "Research on Optimization of Order Processing System of A Company under E-commerce Environment," M.S. thesis, Jinan University, Guangzhou, China, 2018.

[23] M. Jiang, "Research on Internal Control of Inventory Management of A Pharmaceutical Company," M.S. thesis, Hebei GEO University, Shijiazhuang, China, 2018.

[24] F. Yu, "Research on Optimization Strategy of Factory Warehouse Management," M.S. thesis, Beijing University of Posts and Telecommunications, Beijing, China, 2018.

[25] Y. Wang, "Design and Implementation of Information System for Production Logistics Oriented to Milk Powder Industry," M.S. thesis, Beijing University of Posts and Telecommunications, Beijing, China, 2018.

[26] S. Li, "Discussion on Optimization of Logistics Management of BG Company," M.S. thesis, Guangxi University, Nanning, China, 2017.

[27] C. Liang, "Research on Warehouse Management of Small and Medium-sized Pharmaceutical Enterprises," M.S. thesis, Nanchang University, Nanchang, China, 2017.

[28] Y. Wang, Research on Teaching Methods of Logistics Warehouse Management" Course in Higher Vocational Colleges," Economic & Trade Update, no. 7, pp. 288, Jul. 2017.

[29] K. Xue, "Analysis and Implementation of RFID in Warehouse Management of Automotive Business Department of R Group China," M.S. thesis, Shanghai Jiao Tong University, Shanghai, China, 2016.

[30] H. Jing, "Research on Optimization of Sales Logistics Management of UBC Company," M.S. thesis, Jilin University, Changchun, China, 2016.

[31] J. Zhu, “Application Research of Warehouse Management System (WMS) in W Company,” M.S. thesis, Soochow University, Suzhou, China, 2016.

[32] Y. Wu, “Research on Lean Management of Warehouse of A Garment Manufacturing Enterprise,” M.S. thesis, Shanghai Jiao Tong University, Shanghai, China, 2015.

[33] X. Yin, “Research on Warehouse Management Improvement Scheme of S Company under the Background of E-commerce,” M.S. thesis, Soochow University, Suzhou, China, 2015.

[34] C. Wang, “Application Research on Planning and Design of Three-dimensional Warehouse of A Company,” M.S. thesis, Anhui University of Technology, Ma’anshan, China, 2014.

[35] C. Li, “Research on VMI Warehouse Management of S Company,” M.S. thesis, Soochow University, Suzhou, China, 2014.

[36] J. Gu, “Research on Information Management and Operation Management of Material Warehouse,” M.S. thesis, Soochow University, Suzhou, China, 2014.

[37] H. Gao, “Research on Visual Management Technology of Tire Production Line Logistics,” M.S. thesis, Tianjin University, Tianjin, China, 2014.

[38] L. Zhang, “Research on Material Control Management Issues in Manufacturing Layout,” Logistics Technology, no. 13, pp. 34-36, 2013.

[39] O. Ye, J. Zhang, and J. Li, “A Survey on Chinese Data Cleaning,” Computer Engineering and Applications, vol. 48, no. 14, pp. 121-129, Apr. 2012.

[40] S. Cui, “System Analysis and Optimization Based on RFID Warehouse Management,” M.S. thesis, Tianjin University of Science & Technology, Tianjin, China, 2012.

[41] J. Huang, K. Liang, and C. Su, “Analysis on the Problems and Countermeasures of K Warehouse Management,” China Market, no. 15, pp. 74-75, 2012.

[42] M. Mu, “Research on Optimization of Logistics Warehouse Management of DB Company Suzhou Park,” M.S. thesis, Soochow University, Suzhou, China, 2012.

[43] T. Chen, “Design and Implementation of Warehouse Management System for Tobacco Enterprises Based on RFID,” M.S. thesis, Shanghai Jiao Tong University, Shanghai, China, 2012.

[44] L. Shi, “Integration and Service of Warehouse Management System of Third-party Logistics Enterprises,” M.S. thesis, Fudan University, Shanghai, China, 2011.

[45] H. Liao, Y. Dong, and C. Liu, “A Survey on Enterprise BI Application Research,” Enterprise Vitality, no. 3, pp. 87-91, Mar. 2011.

[46] Y. Liao, “Layout Optimization and Management Information System Development of Steel Plate Warehouse of Shipyard,” Ph.D. dissertation, Dalian University of Technology, Dalian, China, 2010.

[47] X. Gu, “Overview of the Application of Data Mining Technology and Customer Relationship Management,” Software Guide, no. 2, pp. 145-146, Feb. 2010.

[48] D. Zhao, “Analysis and Application of Warehouse Management System of Airport Property Company of Civil Aviation,” M.S. thesis, Harbin Engineering University, Harbin, China, 2008.

[49] X. Wang, “Review and Prospect of Database Technology in 2007,” Information Systems Engineering, no. 3, pp. 58-64, Mar. 2008.

[50] Y. Zhang, “Design and Implementation of Information Management System for Container Freight Station Based on J2EE,” M.S. thesis, Tongji University, Shanghai, China, 2006.

[51] H. Zhang, C. Zhang, and H. Xue, “Motivations, obstacles and path selection of enterprise digital transformation,” China Industrial Economics, no. 4, pp. 5-23, 2020.

[52] X. Li and S. Feng, “Analysis of innovative strategies for warehouse management under smart logistics,” China Storage & Transport, no. 11, pp. 142-144, 2019.

[53] M. Zhang and B. Xu, “Innovation of human resource management in enterprise transformation in the digital age,” Enterprise Management, no. 10, pp. 74-76, 2018.

[54] C. Ai and J. Huang, “Development and application of human-machine collaboration in manufacturing industry under the background of Industry 4.0,” Automation Instrumentation, vol. 39, no. 9, pp. 1-6, 2018.

[55] Z. Li and K. Wang, “Application and prospect of artificial intelligence in intelligent manufacturing,” Automation Instrumentation, vol. 40, no. 7, pp. 1-6, 2019.

[56] H. Wu and X. Li, “Review and prospect of industrial artificial intelligence development,” Acta Automatica Sinica, vol. 46, no. 11, pp. 2045-2060, 2020.

[57] X. Chen, K. Huang, and X. Dong, “Robotic technology and its development trend in intelligent manufacturing,” Journal of Mechanical Engineering, vol. 54, no. 9, pp. 27-44, 2018.

[58] X. Xu and Y. Wei, “Research on challenges and countermeasures of artificial intelligence industrialization,” Strategic Study of CAE, vol. 20, no. 3, pp. 13-18, 2018.

[59] F. Lu and H. Lu, “Research on warehouse management based on Internet of Things under the background of smart logistics,” Logistics Engineering and Management, vol. 41, no. 7, pp. 66-68, 2019.

[60] F. Wang, “Parallel Internet of Things: The cornerstone of smart cities and intelligent economy,” Acta Automatica Sinica, vol. 45, no. 11, pp. 1969-1986, 2019.

[61] D. Zheng, Q. Liu, and X. Gu, “Architecture and key technologies of industrial Internet for intelligent manufacturing,” Computer Integrated Manufacturing Systems, vol. 25, no. 4, pp. 690-702, 2019.

[62] J. Chen, X. Zhang, and Y. Wang, “Digital twin workshop: A new approach to realizing intelligent manufacturing in workshops,” Computer Integrated Manufacturing Systems, vol. 23, no. 1, pp. 1-9, 2017.

[63] H. He and H. Hu, “Big data analytics in the Internet of Things: Review and prospects,” Journal of Computer Research and Development, vol. 55, no. 1, pp. 217-234, 2018.

[64] X. Chai, C. Lu, and X. Wang, “Review on industrial Internet security situation awareness technology,” Journal of Computer Research and Development, vol. 56, no. 3, pp. 625-650, 2019.

[65] Z. Zhang, “Supply chain financial risk management based on blockchain technology,” Forum on Science and Technology in China, no. 12, pp. 60-66, 2018.

[66] X. Wang, Q. Ma, and G. Chen, “Review on the application of blockchain technology in agricultural product supply chain traceability,” Science and Technology of Food Industry, vol. 39, no. 22, pp. 321-326, 2018.

[67] J. Lyu, J. Zhu, and D. Zhang, “Current situation, problems and prospects of blockchain technology application in supply chain finance,” Finance Theory & Practice, no. 11, pp. 28-34, 2019.

[68] Z. Miao, L. Fan, and J. Zhao, “Review on the application of blockchain technology in supply chain management,” Computer Integrated Manufacturing Systems, vol. 25, no. 9, pp. 2278-2295, 2019.

[69] J. Zou, W. Xu, and J. Zhao, “Blockchain-based supply chain management: Status, challenges and prospects,” Journal of Software, vol. 30, no. 6, pp. 1841-1862, 2019.

[70] J. Zhu, C. Wan, and P. Jiang, “Research status and development trend of automated stereoscopic warehouse,” Logistics Technology, vol. 37, no. 9, pp. 144-147, 2018.

[71] B. Liang and S. Wang, “Laser SLAM technology and its application in intelligent logistics vehicles,” Logistics Technology & Application, vol. 24, no. 11, pp. 146-149, 2019.

[72] B. Liang and Y. Wan, “Research progress and application of soft robotics technology,” Robot Technique and Application, no. 6, pp. 12-17, 2018.

[73] X. Wang, X. Jiang, and Q. Shen, “Review on smart logistics in intelligent manufacturing,” Computer Integrated Manufacturing Systems, vol. 24, no. 7, pp. 1724-1736, 2018.

[74] N. Li and H. Chen, “Bottlenecks and breakthrough paths of China’s robot industry development,” Journal of Macro-quality Research, vol. 6, no. 4, pp. 110-121, 2018.