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Research on the Impact of Internet of Things (IoT) Technology on Logistics Warehouse Management

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Abstract: As a consequence of the evolution of the times, Internet of Things technology has made remarkable progress in the field of logistics and warehouse management. Its application promotes the intelligence of logistics management. This has the effect of markedly enhancing the efficiency of logistics management, thereby facilitating the accelerated growth of the logistics industry. This paper begins by examining the current state of logistics warehouse management and the fundamental principles of IoT technology and its application in the field of logistics. It then proceeds to discuss the challenges faced by traditional logistics warehouse management in China. This paper analyses how the application of IoT technology can significantly improve the efficiency of logistics management, and provides an in-depth discussion on the development trend of logistics warehouse management. The objective of this paper is to illustrate the pivotal role of IoT technology in logistics warehouse management and to highlight its beneficial influence on the prospective evolution of the logistics industry.

Keywords: Internet of things technology, warehouse management, logistics management.

1. Introduction

The effective management of warehouses is a fundamental aspect of contemporary logistics activities, forming the nucleus of logistics management. It is of great importance in modern warehouse management to efficiently, accurately and comprehensively grasp the detailed information of commodities in the warehousing process and ensure the safe storage of commodities. The advent of the Internet of Things (IoT) has precipitated a diversification in the technological perception of logistics warehouse management systems, with the emergence of new sensing technologies, machine-to-machine (M2M) communication, Bluetooth, video recognition and other forms of data capture [1]. The Internet of Things (IoT) is regarded as a significant enabler of productivity, contributing to the rapid development of the global economy. Its technical architecture comprises three layers: the perception layer, the network layer and the application layer [2]. The field of logistics warehouse management encompasses a multitude of elements, including a vast array of commodities and a diverse range of complex types. The work of logistics warehouse management is inherently challenging. The traditional logistics warehouse management system has proven inadequate in the context of the accelerated pace of modern society. This has led to a clear requirement for the application of advanced Internet of Things technology in logistics warehouse management, with the objective of ensuring the smooth functioning of logistics operations. As the diversity and complexity

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of customer orders increase, the accuracy of real-time data and information must also increase. It is therefore necessary to adapt traditional warehouse operations to meet the needs of the modern manufacturing industry. The Internet of Things (IoT), a pivotal technology in Industry 4.0, presents novel avenues for enhancing and optimising warehouse management systems.IoT technology plays an important role in the field of warehouse management, specifically, IoT technology can be applied to real-time monitoring of goods, tracking inventory dynamics, forecasting changes in demand, managing inventory levels, and other aspects of warehouse operations [3]. The core function of a warehouse is to ensure a smooth sales process and enhance customer satisfaction. By deploying IoT, companies can achieve improved financial benefits, enhanced labour efficiency and increased customer satisfaction [4]. At present, logistics companies in various countries are making efforts to use IoT technology, but due to the complexity of warehouse management as a system itself and the different characteristics of each warehouse, the general charter to promote the use of IoT technology in China and summarise its commonalities still lacks a certain degree of universality. This paper aims to fill the gaps in the domestic research field of IoT technology in logistics warehouse management, and improve the guiding theory of the use of IoT technology. At the same time, it explores the strategies and actions taken by traditional logistics warehouses and logistics warehouses using IoT technology to face the challenges, combined with detailed research methods and analysis frameworks.

2. Logistics warehouse management status and logistics warehouse management in the main use of the Internet of Things technology

2.1. Logistics warehouse management status quo

In recent years, the expansion of online shopping platforms, including Taobao and Pinduoduo, has led to a notable surge in China's logistics industry, which has now become a significant contributor to the country's economic landscape. The latest data on social logistics costs, released by the National Development and Reform Commission of the People's Republic of China, reveals a continued growth in the total cost of social logistics in the country. Despite the deceleration of the growth rate of logistics costs over the past two years, the total volume of logistics remains considerable, reaching 352.4 trillion yuan, according to the latest statistics for 2023. This trend has prompted many logistics and warehousing companies to prioritise the optimisation of warehouse management practices. China has recently placed a greater emphasis on logistics and warehouse management. However, the rate of improvement in these areas is still inadequate in comparison to the rapid pace of development observed in the industry. Over the past decade, China has allocated a significant proportion of its gross domestic product (GDP) to logistics expenditure, with the ratio being approximately twice that of developed countries. This reflects the inefficiency, specialisation and socialisation of logistics and warehousing management in China, which has resulted in the need to bear higher logistics costs to support rapid economic growth. The current process of logistics and warehouse management is characterised by a multitude of intricate details, with numerous segments of the process still reliant on manual operation and supervision. This practice not only results in the consumption of a considerable amount of human and material resources, but also has an impact on the profit margin of the enterprise. It is therefore evident that enhancing the efficiency and automation of logistics and warehouse management represents a crucial step in promoting the growth of the industry, reducing costs and enhancing the competitiveness of enterprises[5].:

2.2. Internet of Things (IoT) technology mainly used in logistics warehouse management

The Internet of Things (IoT) [6], also known as the "Internet of Everything", is regarded as a significant advancement in the information industry, following the advent of computers and the Internet. It represents a pivotal aspect of the emerging generation of information technology. It

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represents a further extension and expansion of the network based on the Internet. The Internet is a vast network that has been formed by combining a variety of information-sensing devices with the network. This has enabled the interconnection, information exchange and intelligent service of people, machines and things at any time and place. The Internet of Everything represents a significant advancement in human scientific and technological history, with profound and far-reaching implications for social production and daily life.

The primary Internet of Things technologies employed in logistics and warehouse management include data fusion technology, information acquisition technology, and RFID technology, among others.[7]

2.2.1. Data fusion technologies

In the context of the IoT, sensors represent a fundamental component, and the existence of sensors and network nodes comprising these sensors is essential for the collection of information. This enables the accurate delivery of information from each node to other locations where it is required. However, this technology has the obvious disadvantage that there is no way to filter the information during the process of use, thus generating a large amount of invalid information that encroaches on the memory. With the advancement of technology, the current stage of data fusion technology has been able to achieve high-speed processing of information, eliminating the invalid information, to meet the real needs of the user. This improvement is undoubtedly also very suitable for the complex environment of the logistics warehouse.

2.2.2. Information Acquisition Technology

The accumulation of data serves as the foundational pillar for the efficient operation of IoT technology. Rather than functioning autonomously, IoT technology is commonly integrated with other technological systems to optimize its capabilities. A notable example is the utilization of RFID technology, which facilitates the extraction of information by scanning two-dimensional codes. Additionally, the combination of RFID with various complementary technologies can result in a spectrum of distinct applications and outcomes, demonstrating the adaptability and versatility of these interconnected systems.

2.2.3. RFID technology

Radio frequency RFID technology is comparable to barcode technology in that both utilise scanning to identify objects. The distinction between the two technologies lies in their respective functions. Barcode technology is primarily utilized to obtain information associated with an object that has been affixed to a barcode. In contrast, RFID technology employs the use of RFID readers to scan RFID tags embedded within objects, thereby facilitating the retrieval of the associated information. Typically, RFID technology is implemented as a comprehensive system, comprising tags, readers and dedicated data management libraries. The fundamental principle of the technology is the automatic identification of two-way traffic via a wireless video signal. The identification process is not subject to human intervention, thereby rendering the technology suitable for use in complex and harsh environments. Furthermore, the technology is capable of providing assistance to people in a variety of settings with a high degree of accuracy and efficiency.

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3. Traditional Logistics Warehouse Management and Logistics Warehouse Management Using IoT Technology

3.1. Traditional Logistics Warehouse Management

The traditional models of warehouse management have become increasingly inefficient and ill-suited to the demands of the modern market. In light of the heightened demand for flexibility, responsiveness and agility in the market, traditional systems are no longer deemed sufficient to address the challenges faced by modern supply chains[8]. This illustrates the shortcomings of conventional warehouse management models and the necessity for innovative technologies and methodologies to enhance efficiency and align with the requirements of contemporary supply chains.

The following issues frequently arise in the context of traditional logistics warehouse management:1. The aforementioned issues collectively contribute to a notable decline in operational efficiency. In the past, the management process was unable to refine management practices and access information technology. This resulted in difficulties in dealing with the complexity of commodity information, which in turn led to a significant reduction in the timeliness of management. The traditional logistics warehouse management model is no longer fit for the purpose of the modern market. As market demands for immediacy and rapid response increase, traditional systems may be unable to process information and tasks in a timely manner. In particular, the two phases of items entering and exiting the warehouse have been conducted manually, precluding modernisation and resulting in markedly low efficiency[9].2. The warehouse layout is generally poor. At this stage of development, the layout of various types of logistics warehouses exhibits a high degree of similarity, with goods often concentrated in a specific area rather than distributed evenly across multiple locations. It is not uncommon for warehouses to be overloaded in one area while the most effective area has a significant amount of remaining space. Such a phenomenon undoubtedly resulted in a significant waste of resources, which had a detrimental impact on the economic efficiency of enterprises.3. Insufficient responsiveness In the context of supply chain management, the capacity to respond expeditiously to alterations is of paramount importance. It is possible that traditional warehouse management systems may be unable to adapt rapidly to changes in orders, fluctuations in inventory, or other disruptions in the supply chain[9].4. The lack of adequate information sharing. In the context of supply chains, the sharing of information is of paramount importance for the enhancement of overall efficiency. The prevailing systems may impede the dissemination and transparency of information between the constituent segments of the supply chain[9]. 5.The automation process is often hindered by various difficulties. The implementation of automation can markedly enhance operational efficiency and accuracy. However, conventional warehouse management systems may encounter challenges in automating their processes[9].6. Security and privacy concerns. As technology advances, the importance of data security and privacy protection grows. It is possible that traditional systems lack sufficient security measures to prevent data leakage or unauthorised access.7. Environmental impact and energy consumption. It is possible that traditional warehouse management does not fully utilise energy-efficient technologies and sustainable practices, which could result in energy wastage and an adverse impact on the environment[9].

3.2. Logistics warehouse management using IoT technologies

The paper, entitled "Vision of the Internet of Things", The paper, entitled "Applications, Challenges and Opportunities from China's Perspective", provides an overview of the application and development of the IoT in various fields within China [10]. The IoT is utilised to manage inventory, e-commerce logistics, distribution management and order-related operations. The utilisation of smart pallets and racks serves to optimise storage space. The paper presented at the 2nd International

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Conference on Computing 2017 provides an account of contemporary information technology and its deployment in the domains of logistics and warehouse management [11]. The IoT comprises a range of technologies, including RFID, Wireless Sensor Networks (WSNs), middleware, cloud computing services and bespoke IoT applications. These technologies are employed extensively across a range of industries worldwide, particularly in the fields of warehousing, logistics management and supply chain optimisation. Such technologies have facilitated improvements in the efficiency and accuracy of the industries concerned, by providing rich and timely data.

The particular applications of IoT technology in the field of logistics and warehouse management are as follows:1. Application in procurement. The Internet of Things (IoT) technology enables logistics warehouse managers to obtain a real-time understanding of the supply chain information pertaining to warehouse items. By comparing this data with inventory information, they can ascertain the stock status of the objects in question, facilitating the prompt and adequate procurement of materials in response to demand [12]. Such a practice will effectively mitigate the issue of unmet quantities of goods when they are required. Furthermore, the utilisation of Internet of Things technology will facilitate the paperless transformation of the overall ordering process, enhance the speed of communication between the parties, expedite the implementation of decision-making, and enable the tracking of Internet of Things technology throughout the procurement process, from the delivery of goods to the receipt of the entire process.2. The application of warehousing. The management of inventory has consistently been a pivotal aspect of logistics and warehouse operations. This encompasses not only the meticulous monitoring of goods but also the maintenance of comprehensive records and the supervision of personnel. Consequently, the greatest expenditure of manpower and time occurs at this stage of the logistics warehouse management process. The implementation of Internet of Things (IoT) technology enables the implementation of precise and efficient control measures at this stage of the process[13]. Upon placement of an item into storage, it will promptly undergo a scan by an RFID scanner, resulting in the automatic entry of its information into the database. In the event of an error, an alarm will be triggered, whereas in the absence of an error, the item will be stored without issue. This results in a more efficient and accurate process, as the data is entered automatically, eliminating the potential for human error.3. The implementation of the inventory system. Following the implementation of IoT technology, comprehensive data on all inventory items will be recorded and stored digitally. The IoT system will utilise real-time data collection, enabling the comparison of current data with previous records. This allows for the precise determination of the quantity and remaining status of each item. Such a change can assist managers in rapidly acquiring detailed information regarding the specific status of each object, obviating the necessity for a comprehensive physical inventory as was previously required.4. Application in the context of environmental monitoring. The application of logistics network technology enables the creation of an intelligent warehouse management system, which is capable of providing differentiated control for each distinct commodity within the warehouse. The installation of temperature sensors and humidity managers in the areas where different commodities are located, and their connection with the air conditioning system, allows for the automated regulation of temperature [13]. This approach ensures that the temperature and humidity in the current area are consistently aligned with the products' storage requirements Concurrently, the control system can also be configured to establish an early warning line, thereby guaranteeing that any issues arising from a multitude of causes can be promptly identified by the management personnel, enabling the timely implementation of the contingency plan and other measures to prevent damage to the goods.

It is postulated that the implementation of the IoT in warehousing will confer a plethora of advantages to organisations. The implementation of the IoT has transformed the concept of smart warehousing, enabling the realisation of previously unattainable efficiencies. Major industry players such as Alibaba, DHL, Amazon and Bluedart have already integrated IoT into their inventory,

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logistics and warehouse management operations. To illustrate, one might consider the case of Alibaba. In particular, with regard to the optimisation of resources, the protection of the environment, the enhancement of operational efficiency and the pursuit of sustainability, the potential of IoT in warehousing is considerable[14]. The implementation of smart logistics technology facilitates the reduction of unnecessary material consumption and waste through the implementation of accurate inventory management and effective logistics planning. The implementation of intelligent logistics technologies enables e-commerce warehouses to reduce their environmental impacts in a more effective manner. This is achieved, for instance, through the tracking of energy consumption and waste emissions in real time via intelligent monitoring systems, which assist companies in identifying and addressing environmental issues. Alibaba's warehouse model reflects a profound understanding of and dedication to long-term social responsibility. By integrating sustainability practices into the company's strategy and culture, Alibaba not only optimises its own efficiency but also contributes to social and environmental sustainability.

In conclusion, the case of this company demonstrates that conventional logistics and warehouse management practices exhibit a certain degree of inaccuracy. The integration of IoT technology into logistics and warehouse management, however, has the potential to enhance efficiency and precision, reduce human resource consumption, and improve overall operational performance.

4. Conclusion

In conclusion, in the context of contemporary social development, the logistics industry demonstrates considerable potential for growth, with the IoT technology representing a pivotal enabler in this process. The application of Internet of Things technology not only enables enterprises to implement a systematic and efficient management of the logistics process, but also effectively addresses the issues inherent to traditional technology. The implementation of IoT technology facilitates the intelligent, automated and controllable management of the entire logistics process, thereby enhancing the efficiency and quality of logistics warehouse management. Concurrently, it can also diminish the utilisation of financial resources and enhance the overall efficacy of logistics resource utilisation, thereby facilitating the consistent advancement of logistics warehouse management. In particular, the implementation of IoT technology can diminish the necessity for manual operation, mitigate the issues and inaccuracies that arise from such operation, and enhance the efficiency and quality of work. It can be reasonably argued that the appropriate application of Internet of Things technology in logistics warehouse management not only enables enterprises to achieve systematic management of logistics processes, but also facilitates the continuous progress and innovation of the logistics industry. While there are commonalities in IoT technology, it is imperative that each logistics enterprise formulates and implements strategies that align with its unique circumstances, taking into account the distinctive economic, social, and environmental characteristics of its local context. This paper has not yet delved deeply into the comprehensive, long-term data sets accumulated by a company as it transitions from a conventional warehouse management model to one that leverages IoT technology. It is anticipated that future research will delve more profoundly into this domain, offering further insights and refinements.

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