Computer Communications 155 (2020) 58–65

Contents lists available at ScienceDirect

Computer Communications

journal homepage: www.elsevier.com/locate/comcom

Logistics industry monitoring system based on wireless sensor network platform

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ARTICLE INFO

Keywords:
Sensor network
Big data
Logistics monitoring system
Warehouse management
Distribution management

ABSTRACT

With the continuous development of the logistics industry, the relevant technology is becoming more mature, the system is increasingly perfect, and the accuracy requirements for the logistics monitoring system are becoming higher and higher. Traditional logistics monitoring is usually manually recorded, which not only wastes manpower and is inefficient, but also cannot meet the current scale and intelligent development requirements of the logistics industry. The purpose of this article is to study modern logistics monitoring systems based on sensor networks and big data. Based on the in-depth study of three technologies of sensor network, big data and logistics technology, this article integrates the entire warehousing and distribution logistics process, and builds a monitoring system framework combining sensor network and big data based on the wireless sensor network software and hardware platform. Combining the two key methods studied in this paper, the information management process of traditional logistics operations such as outbound and inbound, warehousing positioning and monitoring, and distribution monitoring management are implemented, and the monitoring system is tested on this basis. The test results prove that this system has certain deployment reference significance and practical application value, and can help to improve the informationization and intelligence level of logistics management to a certain extent. In this paper, by simulating 250 concurrent users, the server CPU usage is 56.37%, the server memory usage is 57.13%, and the response time is 1944 ms.

1. Introduction

In the seven major types of logistics activities, most of the three processes of loading, unloading, packaging, and distribution processing have been completed by mechanization and automation, and the remaining warehousing and transportation processes have become the main source of logistics errors. The lack of logistics information leads to these problems cannot be discovered and resolved immediately, and the reasons cannot be recorded for later retrospection and avoidance when errors occur. In the warehousing section, most of the finished products produced by the factory or purchased in the shopping mall are placed manually according to some agreed rules. However, the manual method will encounter many problems when entering and shipping, such as misplacement, difficult to find, inflexible placement, and waste of shelf area. In addition to the problem of storage positioning, the lack of storage monitoring is also an important cause of cargo loss. Existing warehouse monitoring systems are mainly closed-circuit televisions and smoke alarms, such as warehouse high-definition video surveillance systems, smoke alarm systems. The purpose is to prevent warehouse theft and prevent cargo theft and dangerous goods accidents. And most of the system adopts the wired method, and the data transmission is carried out through optical cables or signal lines. The wiring is complicated, the scalability is poor, and the types of monitoring data are limited. In the transportation process, the identification method mainly based on barcodes and paper freight bill numbers can realize logistics informatization to a certain extent, but this informationization is more about tracking the goods rather than real-time monitoring of goods in transit. There is no link between the quality of the goods, the transportation environment and the goods themselves in order to achieve the traceability and control of the entire process of the goods. In particular, valuables and dangerous goods may be shaken, impacted or overturned due to abnormal parcels or transportation processes, which may cause damage to valuables or even loss of dangerous goods, such as huge personnel and property. In addition, barcodes and digital single numbers need to be read visually (close to the barcode identifier or within the range of human eyesight), which is slow and error-prone, and can only be scanned or read at both ends of the transportation link or before and after loading code recording has greater limitations and restricts the efficiency of links such as entering and leaving the warehouse.

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https://doi.org/10.1016/j.comcom.2020.03.016
Received 30 January 2020; Received in revised form 1 March 2020; Accepted 10 March 2020
Available online 12 March 2020

With the continuous development of information technology and people's emphasis on cargo quality and cargo safety, more and more logistics information technologies have been concerned. New solutions have emerged for difficult issues such as cold chain logistics, valuables logistics, and storage positioning. And wireless sensor networks and big data technology have received certain attention in the field of logistics with their respective advantages. But the development of the two has always been two parallel lines, and their respective shortcomings have also led to their failure to meet the actual needs of social life. In recent years, the complementarity of these two technologies has gradually attracted attention. The combination of the two technologies will have broad application prospects, especially in the field of logistics monitoring, which will bring about innovations in monitoring technology and rich economic benefits.

Zhang Y and his team believe that in the Rechargeable Sensor Network (RSN), due to the change of renewable energy over time and limited battery capacity, the energy collected by the sensors should be carefully allocated for data sensing and data transmission to optimize data collection. In addition, the dynamic nature of the network topology should be considered because it affects data transmission. They work together to optimize data collection on the network by considering data sensing and data transmission together. To this end, they designed a data collection optimization algorithm for dynamic sensing and routing (DoSR), which consists of two parts. They designed a balanced energy distribution scheme (BEAS) for each sensor to manage its energy use, and it turns out that the scheme can meet the four requirements put forward by the actual scheme. They also proposed a distributed sensing rate and routing control (DSR2C) algorithm to jointly optimize data sensing and data transmission while ensuring network fairness. In DSR2C, each sensor can adaptively adjust its transmission energy consumption during network operation according to the amount of available energy, and choose the best sensing rate and routing, which can effectively improve data collection. In addition, since recalculating the optimal data sensing and routing strategies based on changes in energy allocation will bring huge traffic for information exchange and calculation, they proposed an improved BEAS to manage the energy allocation in a dynamic environment. A topology control scheme is proposed to reduce the computational complexity. Extensive simulations were performed to prove the efficiency of the proposed algorithm compared to existing algorithms [1]. Hashem and his team believe that the expansion of big data and the evolution of Internet of Things (IoT) technologies have played a significant role in the feasibility of smart city initiatives. Big data provides cities with the potential to gain valuable insights from the vast amounts of data collected from various sources, while the Internet of Things allows highly integrated services to integrate sensors, RFID and Bluetooth in real-world environments. The combination of the Internet of Things and big data is an unexplored research area that brings new and interesting challenges to achieving the goals of future smart cities. These new challenges are focused on business and technology-related issues that enable cities to realize the vision, principles and requirements of smart city applications by implementing key smart environment characteristics. They describe the latest communication technologies and smart-based applications used in smart city environments. By focusing on how big data can fundamentally change the urban population at different levels, the vision of big data analysis to support smart cities is discussed. In addition, a future business model for smart city big data is proposed, and business and technology research challenges are identified. This research can provide a benchmark for researchers and industry in the future development and development of smart cities in the context of big data [2]. QU QI and his team proposed an enterprise-level tobacco logistics management platform solution, using GIS and GPS technology to meet the scheduling, navigation and monitoring requirements in tobacco distribution. Through investigation and analysis of tobacco distribution and delivery procedures, a combination of C /S, B/S, and M/S was used in the system design, basic functions of logistics management, such as geographic data collection, delivery route planning, and implementation of freight vehicle monitoring Wait. The management platform used in a tobacco company in Zhejiang Province shows that the platform realizes intelligent dispatching within the service range of the distribution center, provides better services, and saves distribution costs. In addition, key related issues were discussed, such as how to dynamically manage the location data of cigarette retailers, develop business processes suitable for centralized distribution and delivery, and exchange data with related systems [3].

This article conducts an in-depth investigation and exploration of the current logistics industry and related monitoring technologies. Based on the technical background of combining sensor networks and big data, it proposes new solutions to the key issues of warehouse logistics monitoring, and builds sensor networks for the traditional logistics monitoring process. The overall system framework combined with big data.

2. Proposed method

2.1. Sensor network

2.1.1. Sensor network

Wireless sensor networks are multi-hop self-organizing network systems formed by a large number of sensor nodes deployed in the monitoring area to communicate with each other [4,5]. It is an important technical form of the underlying network of the Internet of Things. Its purpose is to cooperatively perceive, collect and process information about perceived objects within the coverage area of the network area, and send it to observers to collaborate to complete specified tasks. With the increasing maturity of sensor technology, wireless communication technology, embedded applications and microelectronics technology, WSN has gradually met people's access to the environment in any environment, time and place. Because of its self-organization, convenient deployment, high fault tolerance, and good concealment, it is very suitable for environmental monitoring, medical, military environment, target tracking and other fields.

2.1.2. Wireless sensor network architecture

Wireless sensor networks are mainly composed of sensor nodes, sink nodes and management nodes [6]. Sensor nodes have functions such as sensing, signal processing, and wireless communication. Nodes (herein referred to as sensor nodes, hereafter referred to as sensor nodes), while acquiring information packets, are also the forwarders of the information packets, forming a multi-hop ad hoc network, and sending data to sink nodes [7,8]. The sink node is also called a gateway, and it can communicate with external networks in many ways, such as the Internet, satellite, or mobile communication network. Large-scale WSN applications can use multiple gateways to implement flexible networks.

Due to the need to deploy a large number of sensor nodes for environmental awareness, the limitations of influencing factors such as price, volume, power, cause the node's communication distance to be short, and can only exchange data with nodes within its communication range or convergence nodes [9,10]. If you need to access data outside the communication range, you need route forwarding. The processing capacity, storage capacity, and communication capacity of the sink node are stronger than those of the node, and it can realize the conversion between the external network and the sensor network. The convergence node can be considered as an enhanced sensor node, with sufficient and stable power supply, larger capacity of FLASH and SRAM, and multiple communication methods. The communication between the sensor network and the terminal management node is achieved through protocol conversion.

With the development of WSN technology and people's higher pursuit of information collection and environmental control, some derived new sensor network technologies have emerged as the times require. Including wireless multimedia sensor networks that acquire multimedia information such as audio, video, and images, wireless sensor and actuator networks (WSAN) with feedback execution and control capabilities combined with sensors and actuators. The WSN referred to in this article is actually a complete feedback control system with sensing and control capabilities.

2.1.3. Key technologies of wireless sensor networks

(1) Network topology

The self-organizing characteristics of wireless sensor networks determine the importance of network topology to them. A good topology lays the foundation for subsequent research on other key technologies.

(2) Energy consumption issues

In the actual application process, due to site conditions and other reasons, it may not be convenient to replace the battery or set up the power line. Therefore, in the system design, the energy consumption of the node should be reduced as much as possible and the life cycle of the battery should be extended as much as possible.

(3) Data fusion problem

Wireless sensor networks can deploy a large number of sensor nodes to collect environmental information, but too much information will inevitably lead to an increase in network load. How to filter and synthesize data to reduce the data transmission volume of wireless network will be the key issues to reduce energy consumption, improve transmission efficiency and information accuracy. In addition, the time synchronization of nodes, network security issues, and embedded operating systems are also key technical issues in the development and application of sensor networks.

2.2. Big data

2.2.1. Big data

Data is divided into structured and unstructured types. The data that can be directly expressed and stored using a two-dimensional table structure is structured data, which is usually stored in a relational database and processed using Structured Query Language (SQL) [11,12]. The format of various unstructured data such as electronic documents, pictures, audio, and video files is beyond the scope of relational databases, and it also requires analytical algorithms such as iterative logic. The structured type of data in big data exceeds the carrying capacity of existing relational database software by an order of magnitude. On the other hand, big data has to deal with a variety of semi-structured and unstructured data, and needs to quickly and effectively screen and filter the quality of various types of data in a short period of time, and then make timely responses to various business needs. response. The scope of the exploration of big data technology is wider than that of traditional data management technology. It not only includes structured data within a known range, but also the degree of data correlation. It is specifically manifested in three points: the first is to store a large amount of structured and unstructured data; the second is to process a large amount of data in real time; the third is to build an algorithm model and continuously optimize based on real-time data [13,14]. A typical big data technology architecture is shown in Fig. 1:

2.2.2. Big data processing

Mining the value contained in data is the core driving force for the development of big data technology [15]. Big data platforms face the challenge of processing massive amounts of data in a short period of time. When the system is busy, there will be more than 100,000 or even millions of online data processing requests per second. Big data real-time processing technology will be necessary. Big data requires different processing forms for three different types of data: batch processing of static data, real-time processing of online data, and comprehensive processing of image data [16,17].

The real-time requirements of static data are low, but the accuracy and comprehensiveness of the data are very high. Batch processing is usually adopted after storage and calculation [18]. As its name implies, static data is data stored on storage media in a static form, and its accumulation process reflects the continuous precipitation of enterprise data assets. Due to the huge volume of static data, ranging from TB level to PB level, the data accuracy is high, but the value density is low. It also takes a lot of time to process static data, and basically does not provide user–system interaction.

Technologies suitable for batch processing of static data include the MapReduce computing framework. It was first proposed and promoted by Google. It has great advantages in processing large data in a highly parallel and scalable manner. The programming interface is simple. Large-scale big data framework with strong input and output (I/O) capabilities, and easy to understand and use. MapReduce uses the working principle of decomposition first (Map) and then merge processing (Reduce). It can divide large data files and distribute them to multiple computing nodes for parallel processing. After processing, they are summarized. This data processing technology greatly improves the processing speed, has great scalability and high availability. Combining query optimization and indexing technology, the interface of the MapReduce programming model can provide good data processing performance, which is also an important reason why MapReduce has always been a leader in large-scale massive data processing platforms. In terms of fault tolerance, the MapReduce framework itself supports task-level fault tolerance, which will be recalculated after a task failure. (NFS) or Zookeeper to support shared storage. Among the many big data processing models, MapReduce is widely welcomed by big data service providers and quickly applied for its advantages such as good cost performance and scalability, easy to understand, easy to use, and can provide good data processing performance [19,20].

Aiming at the application limitations of batch processing of static data, big data processing technology has been extended to real-time data processing, resulting in two modes of streaming data processing and interactive data processing [21,22]. Streaming data processing realizes real-time data collection. The method is to treat streaming data as an infinite data sequence, and the system processes them in order according to the time labels in the sequence. Interactive data processing can reduce the processing time of massive data to seconds, greatly improving work efficiency.

Interactive data is flexible, intuitive, and easy to use. Even in the face of massive data, you only need to directly input operation commands to achieve processing operations such as creating, querying, updating, and deleting. The processed data results can be used again immediately. Relational database management system (RDBMS) is a widely popular interactive data processing tool. The application of online transaction processing (OLTP) in government, medical and industrial control industries has greatly improved work efficiency, and online analytical processing (The in-depth combination of OLAP) and Data Warehouse enables advanced applications such as data analysis and business intelligence. Non-Relational Databases (NoSQL) emerged at the historic moment in response to this demand. Representative products include MongoDB and HBase. MapReduce requires powerful hardware computing resources and network transmission rates. In order to make up for this shortcoming, the interactive data processing system BerkeleySpark uses memory for data calculation and returns processing results in real time, and can run on a lightweight hardware resource platform to provide data Stream computing, interactive computing, and good fault tolerance.

2.2.3. Big data analysis

Big data analysis faces how to effectively express and interpret data, and learn from historical data, including images, sounds, texts and other formats of data [23,24]. Traditional data research is constrained by limited data expression models, and to a large extent depends on the expression of the data itself, it is almost impossible to expand and predict. Big data technology brings more complex presentation models, which can express and interpret data more effectively. Big data analysis is to conduct in-depth observation of data, to discover the relationships,

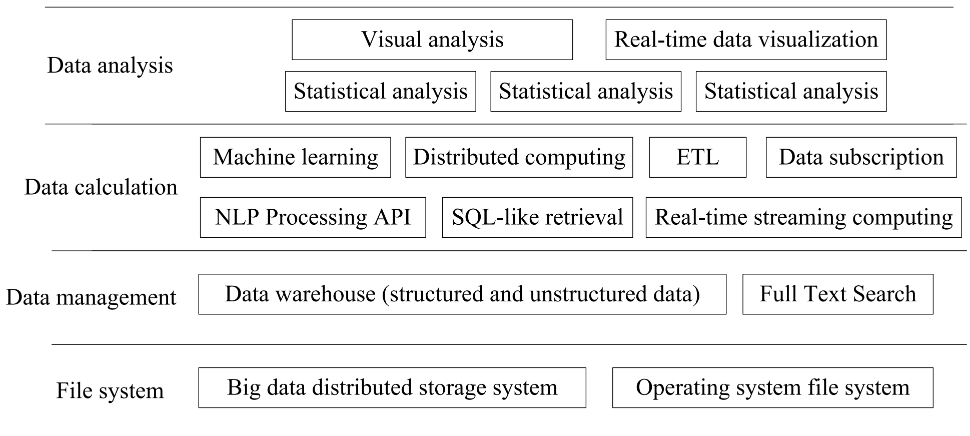

Fig. 1. Big data technology architecture.

patterns and trends that are valuable for decision-making, and then use discovery to establish decision-making models and provide predictive support methods and processes [25]. In the process of big data analysis, appropriate statistical analysis methods and tools are used to extract the most valuable information from the collected data, and play a role in the status quo analysis, cause analysis, and quantitative predictive analysis. Before performing data analysis tasks, you first need to set clear analysis goals and assumptions, and then verify whether the assumptions are correct through comparative analysis, group analysis, cross analysis, regression analysis and other methods. The needs are interpreted, and the corresponding data analysis conclusions are drawn. Data mining technology is to use statistical, artificial intelligence, machine learning and other theoretical methods to mine unknown information with huge commercial value from massive data. It can help companies make decisions, improve operations, improve product quality and market competitiveness. The data mining process includes three stages: data preparation, data mining, result interpretation and evaluation stages. The data mining process is shown in Fig. 2.

Due to the high technical requirements of data analysis tools and the strong technical background required for practical operations, usually only professional technical personnel can better control in actual business, and ordinary business personnel are also difficult to achieve self-service and autonomous analysis, which is impossible. Get business value in time from data. In data visualization technology, by converting data and vision, the filtered information is compressed and deduplicated to achieve multi-scale and multi-level display, which can help business personnel analyze large-scale, multi-dimensional, multi-source and The results of dynamic deepening data are important reference for decision-making. Powerful data visualization technology can effectively display the results of data analysis and play an important role in the process of big data analysis.

2.3. Logistics technology

Automatic Identification Technology (AIT) is an automatic data acquisition technology. It can automatically and quickly identify the information and input it into the information management system. It requires very little manual intervention in the whole process. Automatic identification technology includes barcode identification technology, magnetic card (bar) identification, radio frequency identification, optical character recognition, sound recognition, visual recognition, and so on. In the field of logistics information technology, barcode identification and radio frequency identification are most widely used.

2.3.1. Barcode recognition technology

Bar code technology is a new technology that comes with the development and application of computer information technology. It integrates encoding, printing, identification, data collection and processing. A bar code is a graphic identifier, consisting of black bars and spaces of different widths, arranged in accordance with certain coding rules. After being reflected by the light source emitted by the barcode scanner, it is received by the scanner and converted into the corresponding electric signal according to the strength of the optical signal. Therefore, the bar symbol information is recognized as digital and character information. The bar code can indicate the manufacturer, manufacturer, product name, production date and other information of the goods, so it is fully applied in the field of logistics. At present, the fine-grained management based on bar codes can be realized in the areas of material storage, storage, classification, inventory, and transportation.

2.3.2. Radio frequency identification technology

Radio frequency identification technology (RFID) is a non-contact automatic identification technology for radio frequency communication. RFID tags have the characteristics of small size, large capacity, long life, and reusability, and can support fast reading and writing, non-visual recognition, mobile recognition, multi-target recognition, positioning and long-term tracking management. The combination of RFID technology with the Internet, communication and other technologies can achieve global target tracking and information sharing.

3. Experiments

3.1. Data collection

The data of the system in this paper comes from RFID tags and sensor nodes, which are attached to the goods packaging, and perform data transmission with the fusion node through a reader or wireless transceiver unit. The fusion node processes the data collected by the tag or sensor node, executes part of the monitoring algorithm, and can expand a variety of sensors to directly implement environmental parameter collection or connect to the environmental control system to implement feedback control such as lighting and temperature. Nodes are both the acquirers and the forwarders of information, forming a multi-hop self-organizing network that aggregates data to the converging nodes. The sink node communicates with the external ground network system via Ethernet or GPRS.

3.2. Experimental environment

The development environment of the system in this paper is divided into hardware environment and software environment, the specific configuration is shown in Table 1:

The establishment of the test environment largely determines the test results of the system and the actual application effect. Therefore,

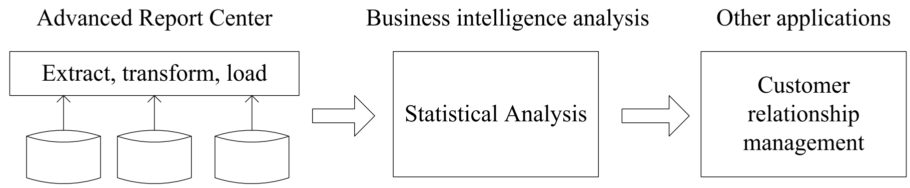

Fig. 2. Data mining process.

Table 1
Development environment.

Hardware environment			Software environment	
Hardware	Size	Version	Software	Version
CPU		Intel	Operating system	Windows10
RAM	4G		Mysql	5.7
Hard disk	250G		Eclipse	4.7
			Tomcat	8.5.11
			JDK	1.9.0
			Java	9.0

Table 2
Test environment.

Name	Size	Version
Linux		Ubuntu
RAM	16G	
Operating system		Windows10

when setting up the test environment, either deploy the system directly to the customer's actual application environment or simulate the real Test environment, the test environment is shown in Table 2.

3.3. System architecture

3.3.1. Overall system architecture

The system platform consists of a perception layer, a network layer, a big data platform layer, and an application layer. The overall system architecture is shown in Fig. 3.

(1) Perception layer: This layer has hardware facilities such as mobile devices, RFID, sensors, and collects relevant information about items in the logistics process.

(2) Network layer: The sensor network, mobile communication network, and Ethernet Unicom are implemented with the help of existing network resources. These network resources include: community private networks, wireless communication networks, and urban fiber optic networks. One layer of network infrastructure settings. The cloud computing platform layer and network layer are connected through an interface. Because the interface is unified, data can be complete and stable during data transmission.

(3) Big data platform layer: The big data platform layer uses core technologies such as virtualization technology and distributed data storage technology to store, process, and analyze uploaded massive data.

(4) Application layer: The application layer is divided into a customer relationship management module, a warehouse management module, an order management module, and a distribution management module according to the system functions.

3.3.2. System function architecture

According to the overall architecture design of the logistics monitoring system, the system is divided into a customer management module, a warehouse management module, an order management module, and a distribution management module. Among them, the warehouse management module has four functions: warehouse management, warehouse management, warehouse management, and inventory management; the distribution management module is divided into two functions: the scheduling subsystem and the monitoring subsystem; the order management module includes the order processing module and the order Inquiry module, out of stock processing module, return processing module, picking processing module and other functions; the customer management module includes two major functions: basic information management and customer credit management. Each of the four modules undertakes its own business and is independent and interconnected with each other.

4. Discussion

4.1. Analysis of system function test results

4.1.1. Outbound management module

The warehousing process includes two processes: arrival and acceptance of the goods and acceptance of the goods after the goods arrive. For goods using RFID tags, after the goods arrive, the readers are used to scan the goods in batches at the entrance of the warehouse, and the goods can be counted and verified. For handheld readers, they can be uploaded to a computer system via a wireless module, while fixed readers can be uploaded to the system via a wired method. After matching the order information, they can be sent to the computer system to generate a warehousing order and assign a designated storage location or Store on the shelf, and notify the shipper that the goods have been received, and complete the warehousing process. The storage management module is shown in Fig. 4.

As can be seen from Fig. 4, this module contains two basic pages for cargo storage and storage record query. When the goods arrive and are scanned by the reader of the crossing, the module will read and upload the EPC code of the goods. The information matches the order to be stored in the system. If the storage conditions are met, the detailed information is automatically generated in the input box on the page. The administrator allocates the target warehouse and shelf, and fine-tunes the automatically generated information or clicks directly to save Finished storage.

4.1.2. Transportation management module

Transportation is the most important part of the entire logistics process, and it is also the process of directly transferring the space position of goods. And how to minimize the change of items and the transportation time during the transfer process are the most concerned issues in transportation management. The transportation management module designed in this paper mainly makes up for the lack of monitoring of the safety of goods in transit. During the transportation process, the reader is used to scan the attachment of the goods to verify whether the goods are in the vehicle. If the tag signal is lost, an alarm command is issued. Secondly, the acceleration sensor attached to the package is used to obtain the three-dimensional acceleration of the cargo, and then the collected data is calculated to determine whether the cargo has abnormal behavior. And upload it to the server through the GPRS module of the first-level convergence node to update the system logistics information, and update the tag transportation information through the reader. If no abnormal behavior is detected, continue to wait. The cargo distribution monitoring module is shown in Fig. 5.

As shown in Fig. 5, the cargo distribution monitoring module mainly includes two parts, a new distribution order, and monitoring of the

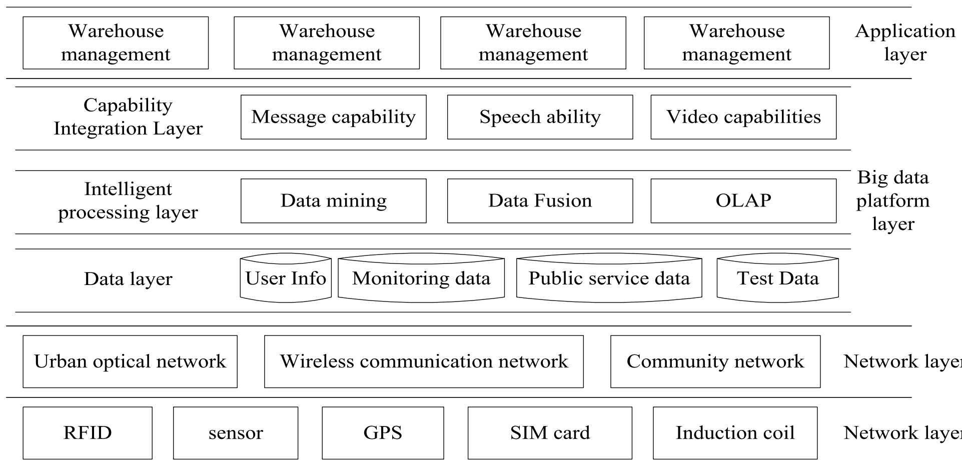

Fig. 3. Overall architecture of the system.

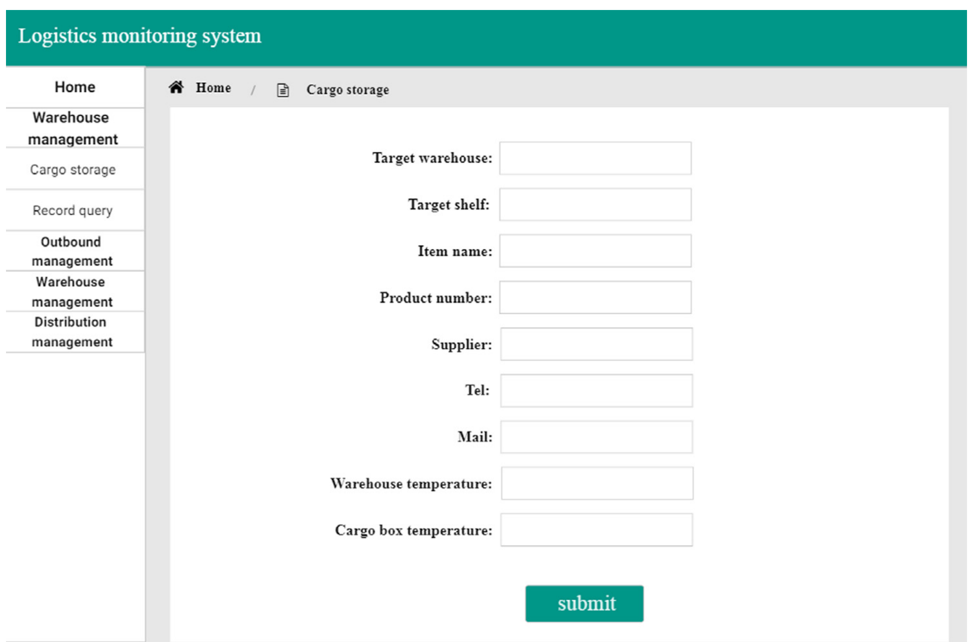

Fig. 4. Warehouse management module.

distribution of goods. For the delivery of goods, take the document number as the entry, and give the main information such as the name, number, quantity, distribution time, distribution place and distribution method of the document under the document number. Click Details to view the delivery monitoring details of this order number, including the temperature, humidity, and abnormal behavior information of the cargo box on the way.

4.2. Analysis of the performance test results of the storage environment monitoring module and system

4.2.1. Warehouse environment monitoring module

WSN's rich sensor interface can realize multi-directional real-time monitoring of the storage environment. As shown in Fig. 6, for temperature and humidity sensitive goods and dangerous goods, WSN can be used to implement environmental monitoring, and the quality and safety of goods can be detected on the side. For controllable environmental variables, we can use WSN to directly control such as insulation systems, lighting systems, to achieve automatic feedback control and maintain a stable and reasonable storage environment. In order to save energy consumption, nodes can adopt a sleep mechanism. If the storage environment is within the normal threshold range, the converging node is in a sleep state. Once the threshold is exceeded, an alarm is issued or automatic control is performed. The storage environment monitoring module is shown in Fig. 6.

From Fig. 6, we can see that the main detection of temperature and humidity information of the environment, according to actual needs can be added different sensors such as ethylene concentration, smoke alarm sensors. The data is compared with the set threshold. If the threshold is exceeded, the status bar displays "abnormal" and reminds the administrator. The administrator can click on "Details" to view or correct the threshold.

4.2.2. System performance test

When performing performance testing, you choose to use LoadRunner to test each function of the system. During the test, you can perform concurrent tests by simulating 10, 30, 50, 70, 90, 110 concurrent users, and test the functional modules that are used more frequently. The duration is 10 min, which records the CPU, memory, and operation

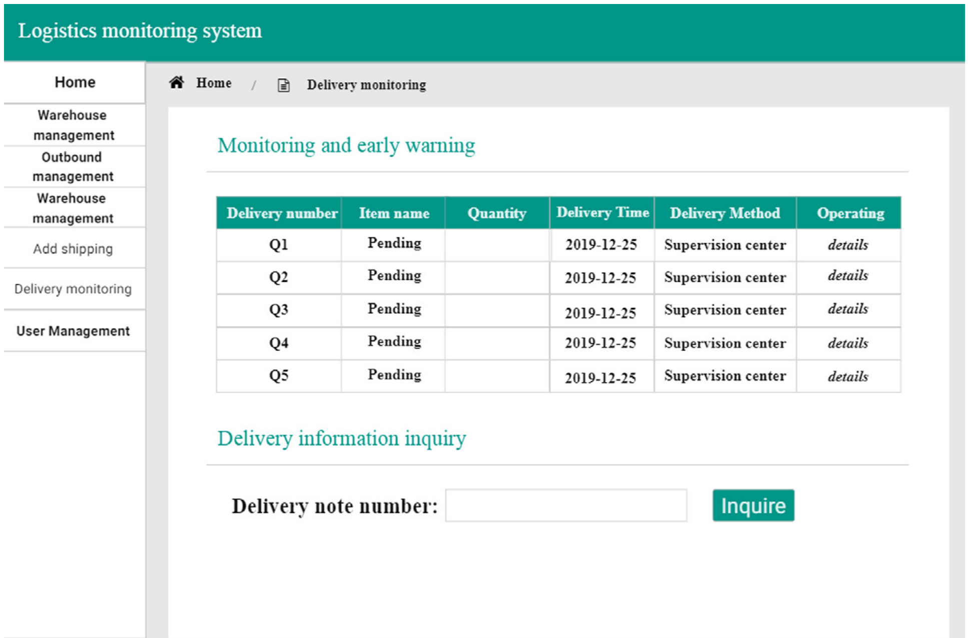

Fig. 5. Cargo distribution monitoring module.

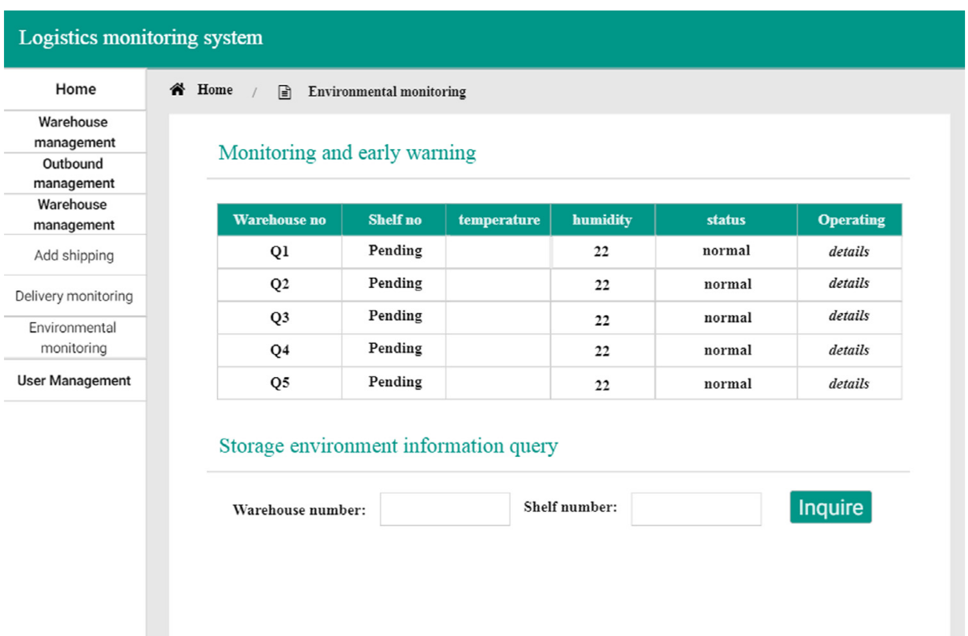

Fig. 6. Warehouse environment monitoring module.

Table 3
Performance test results.

System concurrency	10	50	100	150	200	250
Server CPU usage (%)	8.81	18.12	31.23	40.18	49.33	56.37
Server RAM usage (%)	9.14	22.11	34.45	39.11	51.33	57.13
Response time (ms)	211	346	960	1171	1537	1944
Test duration (s)	10	10	10	10	10	10

response time of the system server when each function is running. Performance test results are shown in Table 3 and Fig. 7.

After testing the performance of each function of the system, it is determined that the system meets the performance requirements proposed by the system when the number of concurrent users is 50, and the average response time of the system is within 3 s when related business operations are performed. Analyze the situation and allow the average response time to be within 5 s. When the number of concurrent operations is 250, the CPU usage of the application server and database server must not exceed 60%, and the memory usage cannot exceed 60%.

5. Conclusions

(1) This article builds a logistics monitoring system based on sensor networks and big data. This system uses sensors and other equipment to collect logistics information data in real time and upload it to the big data platform for data analysis and processing to provide a full

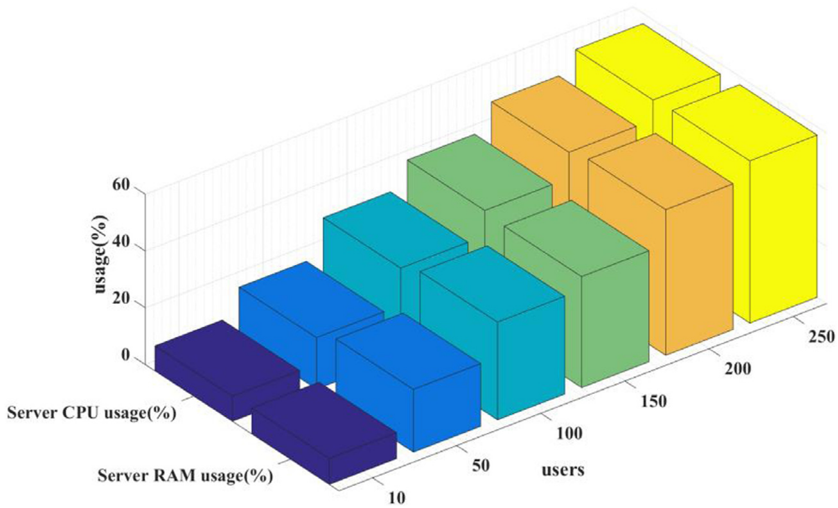

Fig. 7. Performance test results.

range of logistics services; using the big data platform and the web terminal, it provides logistics services that meet the diverse needs of users, builds warehouse management, distribution management, order management, and customer relationship management are integrated logistics information management systems.

(2) Based on the in-depth study of sensor network and big data technologies, this paper proposes corresponding solutions to the problems in the logistics process. Based on this, the logistics process of the entire warehouse distribution is broadened, and a monitoring system framework is designed to realize the management process of the main business of warehouse logistics.

(3) This paper uses big data technology to build a new type of logistics monitoring system and completes the system architecture design. However, there is still a lack of considerations in terms of security: the system is designed with emphasis on the realization of functions, it is more thoughtful about the stability and ease of use of the system, and it lacks consideration of security.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Jingjing Jiang: Investigation. **Haiwen Wang:** Methodology. **Xiangwei Mu:** Proofreading. **Sheng Guan:** Conceptualization.

References

[1] Y. Zhang, S. He, J. Chen, Data gathering optimization by dynamic sensing and routing in rechargeable sensor networks, IEEE/ACM Trans. Netw. 24 (3) (2016) 1632–1646.
[2] Ibrahim Abaker Targio Hashem, Victor Chang, Nor Badrul Anuar, The role of big data in smart city, Int. J. Inf. Manage. 36 (5) (2016) 748–758.
[3] Qu Qi, Kong Yunfeng, Yan Jiankang, Design and application of tobacco logistics management platform, Tob. Sci. Technol. 48 (1) (2015) 90–95.
[4] Alexander Bertrand, Distributed signal processing for wireless EEG sensor networks, IEEE Trans. Neural Syst. Rehabil. Eng. 23 (6) (2015) 923–935.
[5] Zhuangbin Chen, Anfeng Liu, Zhetao Li, Distributed duty cycle control for delay improvement in wireless sensor networks, Peer-to-Peer Netw. Appl. 10 (3) (2016) 1–20.
[6] S. Misra, G. Mali, A. Mondal, Distributed topology management for wireless multimedia sensor networks: Exploiting connectivity and cooperation, Int. J. Commun. Syst. 28 (7) (2015) 1367–1386.
[7] K.W. Choi, L. Ginting, P. Rosyady, et al., Wireless-powered sensor networks: How to realize, IEEE Trans. Wireless Commun. 16 (1) (2017) 221–234.
[8] Liangyin Chen, Yuanchao Shu, Yu Gu, Group-based neighbor discovery in low-duty-cycle mobile sensor networks, IEEE Trans. Mob. Comput. 15 (8) (2016) 1996–2009.
[9] Nai-Wei Lo, Jia-Lun Tsai, An efficient conditional privacy-preserving authentication scheme for vehicular sensor networks without pairings, IEEE Trans. Intell. Transp. Syst. 17 (5) (2016) 1319–1328.
[10] Xin Tan, Zhi Sun, Ian F. Akyildiz, Wireless underground sensor networks: MI-based communication systems for underground applications, IEEE Antennas Propag. Mag. 57 (4) (2015) 74–87.
[11] Zhanxue Gong, Xiyuan Li, Jiawen Liu, Yeming Gong, Machine learning in explaining nonprofit organizations' participation: a driving factors analysis approach, Neural Comput. Appl. 31 (12) (2019) 8267–8277.
[12] Matei Zaharia, Reynold S. Xin, Patrick Wendell, Apache spark: A unified engine for big data processing, Commun. ACM 59 (11) (2016) 56–65.
[13] Lv Yisheng, Yanjie Duan, Wenwen Kang, Traffic flow prediction with big data: A deep learning approach, IEEE Trans. Intell. Transp. Syst. 16 (2) (2015) 865–873.
[14] Ziad Obermeyer, Ezekiel J. Emanuel, Predicting the future — Big data, machine learning, and clinical medicine, N. Engl. J. Med. 375 (13) (2016) 1216–1219.
[15] Andrea De Mauro, Marco Greco, Michele Grimaldi, A formal definition of Big Data based on its essential features, Libr. Rev. 65 (3) (2016) 122–135.
[16] K. Liu, W. Sheng, D. Zhang, Big data application requirements and scenario analysis in smart distribution network, Proc. CSEE 35 (2) (2015) 287–293.
[17] Yi Chen, Shuai Ding, Zheng Xu, Handong Zheng, Shanlin Yang, Blockchain-based medical records secure storage and medical service framework, J. Med. Syst. 43 (1) (2019) 5:1–5:9.
[18] Kan Zheng, Zhe Yang, Kuan Zhang, Big data-driven optimization for mobile networks toward 5G, IEEE Netw. 30 (1) (2016) 44–51.
[19] Zhou Su, Qichao Xu, Qifan Qi, Big data in mobile social networks: A QoE-oriented framework, IEEE Netw. 30 (1) (2016) 52–57.
[20] R.B. Salako, W. Shen, Global existence and asymptotic behavior of classical solutions to a parabolic–elliptic chemotaxis system with logistic source on R N R N mathContainer Loading Mathjax, J. Differential Equations 262 (11) (2017) 5635–5690.
[21] Roni Leibowitz, Shahar Aflalo, Ornit Cohen, The sherlock system - clinical and logistic pharmaceutical services, Harefuah 155 (8) (2016) 478–481.
[22] A.A. Lempert, A.L. Kazakov, D.S. Bukharov, Mathematical model and program system for solving a problem of logistic objects placement, Autom. Remote Control 76 (8) (2015) 1463–1470.
[23] Chongguang Feng, Hao Hu, Feng Xu, An intelligent logistics management model in prefabricated construction, Front. Eng. Manage. 2 (2) (2015) 178.
[24] Baek Se In, Hong Ryeol Shin, Mee Hwa Park, A study on the management of drug logistics using beacon technology, J. Comput. Theor. Nanosci. 24 (3) (2018) 1979–1985.
[25] G.W. Lailossa, The new paradigm of cold chain management systems and it's logistics on Tuna fishery sector in Indonesia, AACL Bioflux 8 (3) (2015) 381–389.

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检索证明

经检索，蒋晶晶 发表的1篇论文被《科学引文索引》（SCI-E）正式收录（详细信息附后），特此证明。

检索人：姚年媛

大连海事大学图书馆

2020年9月9日

论文的详细信息如下：

Record 1 of 1

Title: Logistics industry monitoring system based on wireless sensor network platform

Author(s): Jiang, JJ (Jiang, Jingjing); Wang, HW (Wang, Haiwen); Mu, XW (Mu, Xiangwei); Guan, S (Guan, Sheng)

Source: COMPUTER COMMUNICATIONS Volume: 155 Pages: 58-65 DOI: 10.1016/j.comcom.2020.03.016 Published: APR 1 2020

Times Cited in Web of Science Core Collection: 0

Total Times Cited: 0

Accession Number: WOS:000528265400007

Document Type: Article

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ISSN: 0140-3664

eISSN: 1873-703X

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COMPUTER COMMUNICATIONS

Impact Factor

2.816	2.944
2019	*5 year*

JCR® Category	*Rank in Category*	*Quartile in Category*
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