Hindawi
Journal of Sensors
Volume 2021, Article ID 4084288, 10 pages
https://doi.org/10.1155/2021/4084288

Research Article

Using Wireless Sensor Network to Remote Real-Time Monitoring and Tracking of Logistics Status Based on Difference Transmission Algorithm

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Received 24 August 2021; Accepted 9 September 2021; Published 25 September 2021

Academic Editor: Guolong Shi

This paper proposes a logistics tracking information management system based on a wireless sensor network, using wireless sensor nodes to track and manage logistics tracking information, and designs a networked logistics tracking information management system to achieve remote real-time management of logistics tracking information. The research work in this paper can mention the real-time and accuracy of logistics tracking information management, which has significant guiding significance to the information security of the logistics industry. This paper first analyzes the business process of logistics enterprises, obtains the demand analysis of logistics tracking management system, divides the whole logistics tracking management system into several functional modules according to the logistics business process of enterprises, analyzes and designs these system functional modules, and gives the model of system functions. After analyzing and designing the system, for the data processing problem in the wireless sensor network, the difference transmission algorithm based on the mean expectation is proposed, which calculates the mean value as the expected value under the specific data model. Then, the data of the difference between the collected value and the expected value is transmitted to reduce the amount of data sent by the nodes, reduce energy consumption, extend the network life cycle, and ensure the stability of the logistics tracking information system. The purpose is to reduce the amount of data sent by nodes, reduce energy consumption, extend the network life cycle, and ensure the stable operation of the logistics tracking information system. In this paper, we describe the logistics tracking system based on a wireless sensor network, which has not only features such as sharing and flexibility but also has high fault tolerance. The system is designed for functional modules such as procurement management, inventory management, and sales management. The JAVA technology platform is selected for design and development, and the SQL Server database is selected for the backend of the system, and a simple and easy-to-use WEB interface for the user service side of the system is designed to meet the needs of a user-friendly environment. The implementation of the system also makes some theoretical and practical contributions to the design and development of similar logistics tracking information management systems based on wireless sensor networks.

1. Introduction

Logistics tracking information is the biggest difference between modern logistics and traditional logistics. The typical representative of the integration of logistics and information is the creation of the logistics tracking information system [1]. It includes information systems in various fields of logistics operation process, involving inbound and outbound, warehousing, transportation, yard, etc. It is a three-dimensional system or a collection of multiple systems formed by computers, communications, and other high-tech equipment connected through a network. From the effect of adopting a logistics tracking information system, it can play an effective monitoring role on the operation condition of each link, which can not only make the use of resources more reasonable but also make the operation cost reduced [2]. The development of logistic tracking information systems is benefited from computer communication technology, and in the field of computer communication, WSN (wireless sensor network) is mostly studied by scholars as a popular research direction. WSN is known for its low cost and low power consumption and can work in a self-organized manner. It can be widely deployed in a variety of production and life scenarios, ranging from manufacturing, health care, and transportation. Universities, commercial research institutions, and even the government and military have all given varying degrees of attention and importance. The logistics industry is destined to develop rapidly in the new millennium. Taking advantage of the current development opportunities, we will vigorously support the logistics industry, which will play a great role in promoting the development of the economy [3]. The development and use of modern logistics tracking information management systems will play a great role in the efficient operation of enterprises. Due to the economic constraints, the logistics industry is at a late start; small scale, technology development is not mature enough; and the current economic development situation is extremely inconsistent, so the active promotion of logistics development will be the economic development imperative [4].

The logistics management system is according to the specific business processes of the logistics enterprises, to be able to easily and quickly transfer data and information about goods, financial, and market aspects within the enterprise. It is necessary to integrate various data from various departments and links to form a data system that can be integrated and processed, so that the functional departments or the upper management of the enterprise can easily access these data and information. The use of logistics tracking information management system saves labor costs at the same time, improving the accuracy and efficiency of the work; for enterprise data and information, queries can be quickly found from the logistics tracking information management system, increasing the convenience of enterprise managers to understand the enterprise information, and make the corresponding strategy, improving the flexibility and competitiveness of enterprises [5]. This paper proposes a logistics tracking method based on a wireless sensor network, by deploying a large number of integrated sensor nodes with certain processing power and wireless communication capability in the logistics process. The logistics objects can complete the identification, tracking, positioning, status monitoring, real-time control, and optimization in logistics operation in a collaborative manner with the support of the nodes. Wireless sensor networks can be customized for the needs of logistics operations and compared to previous technologies; they can not only collect and transmit data but also sense the state information of objects and their surroundings and execute part of the business logic, thus enabling timely information collection, processing and decision-making in logistics processes, and supporting continuous optimization of logistics processes. Wireless communication capabilities enable wireless sensor logistics systems to deploy information acquisition capabilities free from the limitations of traditional network infrastructure and to improve real-time information and accuracy.

This paper develops a logistics tracking information management system based on a sensor network to provide a new logistics operation support platform for logistics enterprises. The logistics system can not only obtain real-time logistics tracking information but also conduct real-time information analysis. Decision-making is based on the information processing capability and communication capability provided by the sensor network, and it can make decision and processing of the events occurring in the logistics process with minimal delay to achieve continuous optimization of the logistics. The first chapter first describes the research of the topic. Chapter 1 first describes the research background of the topic, introduces the relevant background of logistics systems and networks, then describes the significance of studying logistics tracking, and finally introduces the organization of the article. The second chapter introduces the current research status of logistics tracking information management, analyzes the advantages and disadvantages of existing technologies, and then introduces the main research content of the logistics tracking system based on wireless sensor networks. Chapter 3 firstly introduces the design idea of the logistics tracking method based on sensor network, then introduces the overall architecture of the system, focusing on the functional modules of wireless sensor nodes and vehicle gateway, and finally analyzes the business process of the logistics tracking method. And the key technologies to implement the wireless sensor network-based logistics tracking method include the active tracking model based on a finite state machine, and the rule-based event processing and decision-making. Chapter 4 conducts simulation and performance tests on the system and also analyzes the logistics tracking algorithm of the wireless sensor network studied in this paper and analyzes these results. Chapter 5 summarizes the research content and results of this thesis and introduces the focus of future work on system improvement.

2. Related Work

For the processing of logistics tracking information, which is generally based on database operations, wireless sensor networks are different from ordinary computer networks, which are concerned not only with the efficiency of query execution but also with the energy consumption of the network. The focus of WSN optimization is not only on finding the common part of the expression but more on comparing the sequence of operations of logistics tracking information, than the traditional logistics tracking information optimization techniques [6]. Sharma and Koundal point out that the sampling actions can be adjusted according to the cost of the collected data, and one direction of research for optimization is the adjustment of the order of the predicate operations as well as the batch processing [7]. Chéour et al. note that collisions between packets during data transmission may cause delay and energy consumption, and for this purpose, DTA is introduced to optimize a reasonable reconstruction of the routing tree using algebra to avoid collisions and extend the time of collision-free data transmission as much as possible [8]. Skyline computation refers to finding from a data set the set of all points that are not dominated by other data points, which itself is a typical multiobjective optimization problem, and Singh et al. propose a query process processing algorithm based on Skyline located within the data ring region under WSN, which divides the ring by the geographic region of the query target location P as the center and radiates outward [9]. And when querying n Skyline values near the center, the distance smaller than P other attribute values is compared with it, reducing the data size, while the nodes are using a chain-cluster structure between them, and the serial and parallel processing modes work simultaneously in query processing, improving query efficiency and reducing data query energy consumption. After solving the various problems encountered in the operation of WSN itself, it is necessary to consider the application of WSN in logistics tracking information systems and the form of the problem, to determine the scenario of the application of WSN in logistics tracking information systems and how to cascade and configure [10]. In this regard, many scholars and project developers have either given corresponding theoretical studies or implemented WSNs in logistics tracking information systems in real projects [11].

Despite the many superior features of wireless sensor networks, they still face many security issues, for example, battery-powered sensor nodes are not rechargeable and difficult to replace due to cost constraints, so if a large number of nodes die from premature energy depletion, it can lead to serious damage to the network structure, thus affecting the performance and survival time of the network [12]. Fang et al. proposed an autonomous in-transit detection system, which integrates RFID and wireless sensor network; the container is full of vegetables and fruits, in which several wireless sensor nodes for detecting ethylene are deployed; the wireless sensor nodes are responsible for collecting the concentration of ethylene, and RFID technology is used to control and record the loading and unloading process of vegetables and fruits, and each time the wireless sensor nodes collect the logistics information, they send to the backend server for processing [13]. Liu et al. proposed a wireless sensor network-based intelligent monitoring and tracking system for agricultural logistics transportation equipment, which established a wireless sensor network for monitoring the internal parameters of refrigerated containers and connected to the backend server through an intelligent terminal and a wireless mobile network to transmit the logistics data [14]. Osamy et al. proposed a method for medical logistics control and optimization, which uses the wireless sensor network's sensing capability and communication capability, using a service-oriented approach to manage medical resources and save management costs by integrating platform middleware to exchange data and commands between sensor networks and other data networks [15]. Therefore, the wireless sensor query in logistics applications may face more unprecedented challenges and need to be analyzed according to the specific problems of the application scenario, which also triggers more in-depth research and optimization solutions to be proposed.

Wireless sensors have communication, computing, and sensing capabilities that RFID and barcode technologies do not have [16]. By deploying a large number of inexpensive wireless sensor nodes in the logistics process, monitoring and tracking of logistics objects can be realized, which can effectively overcome the problems of RFID and barcode technologies. However, the above research also has its shortcomings and does not make full use of the computational characteristics of the sensor nodes, in the process of logistics monitoring, wireless sensor nodes each time after collecting data without any processing sent to the backend server, and the backend server to make decisions. The rapid changes in logistics will generate a huge amount of real-time data flow, bringing great load pressure on the network and the backend server, at the same time. As each time needs to wait for the processing of the backend server, also it cannot meet the requirements of real-time decision-making [17]. With the development of computer networks, it has become a trend to establish a logistics tracking information management system based on wireless sensor networks. To manage the whole logistics process more easily and conveniently, we introduce a network management system, which can better improve the logistics speed of the enterprise, the commodity turnover cycle, reduce the inventory stock, make the enterprise production more efficient and reasonable, and finally improve the comprehensive economic benefits of the enterprise. Based on the current development situation and bright future of logistics enterprises, we should continuously improve and refine this logistics system and develop it into an advanced and practical logistics tracking information management system that meets the needs of logistics enterprises [18].

3. Design and Implementation of Logistics Tracking Information Management System Based on Wireless Sensor Network

3.1. Logistics Tracking Information Management System Design. The logistics tracking system based on a wireless sensor network is composed of a backend server, warehouse gateway, vehicle gateway, sensor nodes, management terminal, and customer terminal. The backend server, as a bridge between the user and the target cargo, is responsible for providing real-time cargo logistics data to the user as well as maintaining communication with the vehicle gateway. The client terminal obtains logistics data in real-time by connecting to the backend server; the management terminal provides an operational interface for logistics managers to manage logistics resources; the warehouse gateway is responsible for managing and maintaining all sensor nodes in the warehouse; the sensor network is managed by the vehicle gateway, which is responsible for receiving data packets sent by the sensor nodes and writing command information to the sensor nodes; the sensor nodes are responsible for monitoring the transportation status of cargo parcels and collecting the status data of cargo parcels periodically. The system architecture is shown in Figure 1.

The customer terminal provides a real-time view of the data, and the customer connects to the system by logging into the terminal interface provided by the backend server. Customers can purchase the corresponding goods in the system according to their needs, and the backend server generates orders based on the type, quantity, delivery time, and

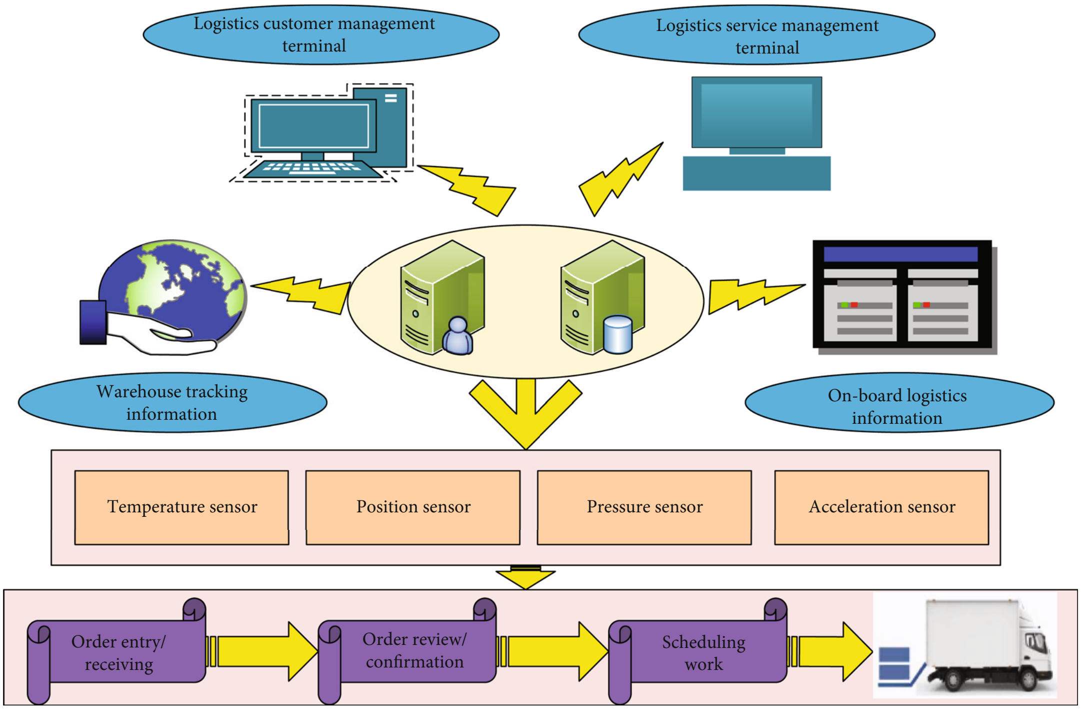

Figure 1: System architecture diagram.

delivery location of the goods, and the management designates the transport vehicles and starts the delivery [19]. Customers can grasp the real-time location and status information of goods transportation in real-time through the data view provided by the backend server in the process of the goods delivery. The management terminal provides the interface of operating system resources for logistics managers, who connect to the backend server through the management terminal [20, 21]. As the manager of the logistics system, logistics managers are responsible for managing and maintaining all resources in the logistics system, including vehicle management, order management, and node management. Logistics managers are responsible for adding, deleting, and changing vehicles and wireless sensor nodes in the system and maintaining their status.

The warehouse gateway is placed in the warehouse and is responsible for managing and maintaining all the sensor nodes in the warehouse, as well as communicating with the backend server. The warehouse gateway records the addition and removal of all sensor nodes in the warehouse and maintains the status of each sensor node. The warehouse gateway accepts the initialization message from the backend server, performs the initialization operation on the target sensor node, modifies its status to be used, and removes the node from the warehouse. The vehicle gateways are installed in the vehicles, and each vehicle gateway corresponds to one vehicle. Since the vehicle gateway is located in the dynamically moving vehicle, the vehicle gateway can communicate with the backend server via GPRS/GSM wireless network, thus ensuring that it keeps in touch with the server during the dynamically moving transportation process and sends the status information of the cargo parcels in the vehicle to the server steadily. The vehicle gateway is also responsible for forwarding the data and commands sent by the server to the wireless sensor nodes, and each vehicle gateway is connected to a base sensor node, which is responsible for forwarding the data generated by the gateway and the node.

The wireless sensor nodes are placed inside the cargo package and loaded into the vehicle together with the cargo package, each wireless sensor node manages one cargo package, all wireless sensor nodes in each vehicle constitute a sensor network, and the vehicle gateway in the vehicle is responsible for establishing the communication between the wireless sensor nodes and the backend server. The wireless sensor nodes send data packets to the base sensor node through the multihop network, and then, the base sensor node sends them to the vehicle gateway. The backend server, as the information center for maintaining various resources of the system, undertakes the task of communicating with other modules and managing various information resources of the system at the same time.

3.2. Wireless Sensor Network Logistics Tracking Algorithm. The improved algorithm based on time introduces the concept of time to scientifically select the appropriate build node to act as the cluster head based on the remaining level reference of the constituent build part; the orientation where the constituent build is located and the data aggregated by the intermediate nodes are the statistics wanted by the central node. The scheme contemplates that the constituent build nodes are disorderly discharged in the overall general environment, the base station is located outside the constituent parts, the sensing node relies on judgment to select the appropriate message, and the cluster head node merges the message before propagating it to the head station.

First, each constituent build sends a message to the headquarters, and the headquarters collects the message and thinks about the distance of the location from the total station concerning the nodes of the existing constituent parts, and then, the headquarters carries out the corresponding response mechanism to distribute the message. The content of the message includes the distance information of the node and the base station as well as the maximum distance. After the message transmission with the head office, the node gets the interval with the head office, this interval will not be changed in the future steps, and this step is used only at the beginning of the initial start. Still retaining the concept of the cycle, the constituent parts send the time t randomly after the start of each cycle; the absence of selective picking of t does not affect the time calculation of the reference build. The timing time of the timer is related to the information factor as shown in

$$F(T) = \frac{I(E) - C(E)}{I(E)} * t + \frac{C(P)}{\max (P)} * f(t) + h, \quad (1)$$

where the remaining energy information factor of the node is $(I(E) - C(E))/I(E)$, the location information factor of the node from the base station is $C(P)/\max (P)$, and the number of times the node has ever been elected as a cluster head factor is $f(t)$. Calculate the time to build the constituent nodes, and after reaching the arranged time point, by comparing the amount of broadcast information of the cluster head received now and h, h is the amount of data contained in the constituent cluster head in the present environment; if it is less than h, the message is issued as becoming a cluster head, expecting participation of other constituent build nodes. If more than h, the build gives up the ability to become the next cluster head and becomes a general member and joins the corresponding cluster.

The routing algorithm relies on its selection of the corresponding environmental subcluster routing scheme, continuous round-by-round operation, and time-consuming message transmission time, which is just the beginning of the cluster construction period, including the initialization of the nodes and base stations that make up the construction. After the communication is done, other build points propagate messages to the cluster head, and the cluster head merges the messages and sends them to the intermediate constituent builds. After the termination of this phase, the whole steps to the next task and picks the cluster heads again. $G(h)$ is calculated as in

$$G(h) = \frac{h}{1 - h(\text{mod } (1/h))}, \quad h \subseteq [1, T]. \quad (2)$$

The method of sending from the transmitter to the terminator during peer-to-peer communication is composed of a trusted transmission mode and a nontrusted transmission mode. The trusted transport mode of reliable transmission has higher energy consumption. The routing protocol relies on the nontrustworthy transmission mode of the constituent constructs with lower energy consumption. Assuming that the lack of resources cluster head dies while the communication is in progress and the constructs within the cluster do not receive the message that the cluster head is gone, the arranged countermeasures will be taken to continue the collection until the termination, which will generate the waste of excess energy of the nodes of the constituent constructs within the cluster.

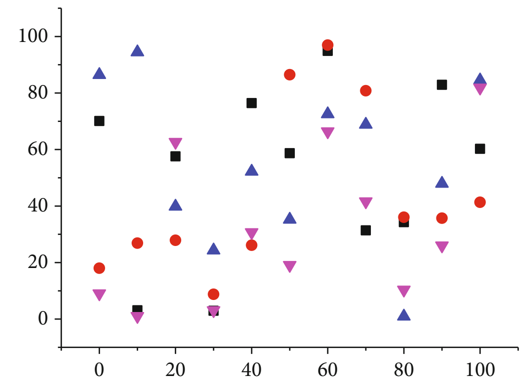

Figure 2: Node distribution map.

The logistics truck is separated into 20 small compartments, and it is assumed that the sensor nodes of each small compartment are uniformly deployed in a 100 cm × 100 cm square closed wireless sensor network. This is shown in Figure 2.

Each node of the sensor network will send the original data until it receives the notification of the predicted value, and once it receives the notification of the update of the predicted value and the predicted value, it will record the predicted value in the local storage space; after that, the node will not send the original data but the difference between the collected value and the predicted value. First of all, in the actual cause of a decimal integer N, the number of bits to be transmitted should be equation (3), where $H(\ln (K))$ means to take down the integer.

$$F(\text{bit}) = \begin{cases} H(\ln (K)) + 1, & K > 0, \\ 1, & K = 0. \end{cases} \quad (3)$$

Let the total number of samples be D, a constant value, and the number of collected data values equal to x_i be D_i. The total data can be approximated as

$$T = \lim_{K \longrightarrow \infty} \sum_{i=0}^{K} \ln(x_i) * D_i, \quad K \subseteq [0, T]. \quad (4)$$

The amount of data for the predicted value-based differential transmission algorithm can be expressed as

$$P = D * \sum_{i=0}^{K} \ln(x_i - t) * p(x_i). \quad (5)$$

The differential transmission signal is highly immune to external interference. The original input signal passes through an inverter and a buffer to form a pair of differential signals of equal size and opposite polarity. For analogy signals, the inverter can be implemented with the inverting proportional amplifier circuit of an operational amplifier, and the buffer can be implemented with the in-phase following circuit of an operational amplifier. For digital signals, "nongate" logic and in-phase buffers can be used, respectively.

In the time-like process, the accumulation of message distance values according to the joining and increasing of the constituent build nodes in the net affects the information table of other constituent build nodes with certain distance difference values. When there are more construction nodes, the information volume between the construction nodes is large and interchangeable, and the load of the nodes in the middle of the composition construction is heavier. This affects the timely transmission of the other building nodes. So the accuracy of the constructed information is the criterion to judge the reliability of the algorithm. The tiny composition build point of the cluster head composition or the next cluster head build node transmits this time value to the terminus at 1 moment and broadcasts it to the whole network, and the terminus receives this sent time value at 2 moments by the corresponding requirements and tells the other composition build nodes the same message time content at 3 moments, and the cluster head composition build point or the next cluster head build node aggregates it at 4 moments and transmits the terminus message content to the whole network to make the time of the whole network are consistent, where F_t is the distance-time value between the two constituent build nodes and G_t is the time difference value of the whole network.

$$\begin{cases} F_t = \dfrac{\left(|T_{i+1} - T_i| - |T_{i+3} - T_{i+2}|\right)}{2}, \\ G_t = \dfrac{\left(|T_{i+1} - T_i| - |T_{i+3} - T_{i+2}|\right)}{2}, \\ i \subseteq [0, t]. \end{cases} \quad (6)$$

3.3. Logistics Tracking Information Management System Implementation. In the inventory management system, when there is an in/out or movement of materials occurs, the inventory management subsystem should make statistics based on the real-time data of the inventory, of which the management of in/out is one of the more important parts of the inventory management system. When inbound materials, the warehouse manager should put the materials into the corresponding storage space according to the regulations and then modify the relevant storage space information and material information and at the same time verify whether the type and quantity of inbound materials are consistent with the inbound list according to the inbound list. After warehousing, the system will also modify the inventory information. Analyze the inventory control process, establish the inventory decision rules for all materials, determine the time for ordering and purchasing accordingly, when the inventory management system shows the need to purchase materials, and submit a purchase application to the purchasing department; the purchasing department selects the supplier and signs a purchase contract with it, the production control department makes a production plan according to the production order, the purchased materials must be inspected for quantity and quality to decide whether to handle the stocking, the production control department makes the production plan according to the production order, and the purchased materials must be inspected for quantity and quality to decide whether they should be returned to the warehouse. Procurement is at the beginning of the business process of a logistics company and therefore plays an important role in the entire production process of the company. For all companies, the purpose of the logistics enterprise is to deliver a specific raw material, finished or semiproduct to a specific address at a specific time. The sensor nodes send the data to the base station, which sends the relevant information to the test platform wirelessly, and the platform processes and displays the collected information.

Procedures are stored in the SQL Server, since the procedure itself, which is a program, and part of that program is written by Transaction-SQL; the processing of data results is achieved by the created application by calling the procedure with parameters accepted by the procedure so that the result set can be returned to indicate whether the call was successful or not; there are also statements used to manipulate the database, and the procedure call can be executed by another stored procedure. Compared to the speed of executing a batch process, stored procedures become much faster when the same operation is executed multiple times, or when the code for a set of operations contains a large amount of Transaction-SQL code. When a stored procedure is executed for the first time, it is analyzed and optimized by the query optimizer because it has been compiled before and is finally given an execution plan, and this final plan is stored in the system tables.

In the logistics management system, the logistics tracking subsystem plays a very important role; it can help enterprises analyze the market information and make rapid response to the changes in the market; through the product in the logistics of each link back to the information, the flow of goods and materials and other information have an understanding of the situation. Tracking and analysis of the flow of information and materials can improve the overall strength of the enterprise. The logistics tracking subsystem contains six main modules: management resources, collation information, external and system interfaces, management communication, evaluation system, and application functions. Order-oriented production is a way to organize production by purchasing and producing according to orders. Order-oriented production has a large share in manufacturing companies. These companies track sales orders and confirm the information on business flow, process execution, and production costs associated with the order. With this form of tracking, it is possible to track configured products as a whole, from sales orders to planning, production, and inventory on their own, maintain and query the customer's bill of materials, as well as batch correspondence tables, and also query order lot tracking tables. When enterprises manage production, production materials are corresponding to finished products, tracking queries of

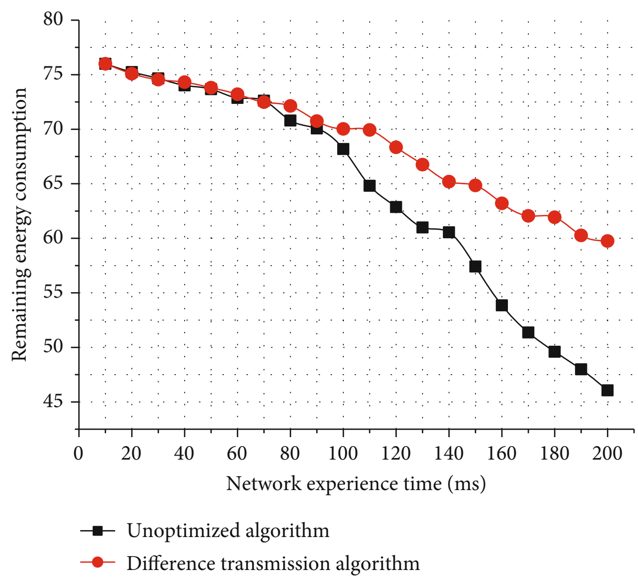

Figure 3: Energy consumption diagram of node 3 under the data model with $f(t)$ of 10%.

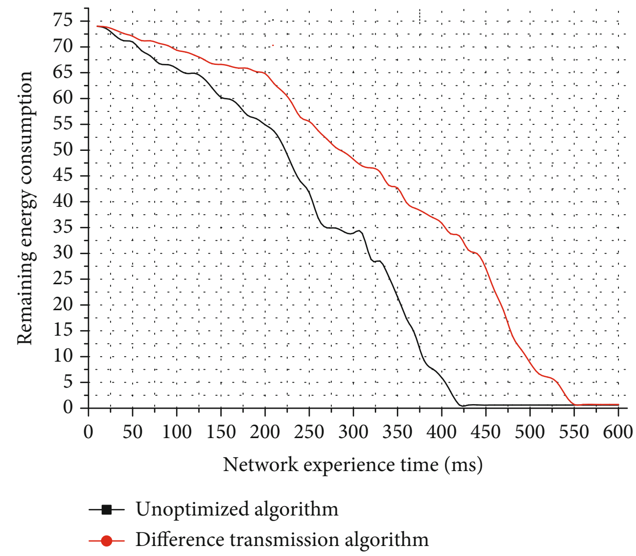

Figure 4: Energy consumption diagram of node 3 under the data model where $f(t)$ is 90%.

production materials, and managing materials by lot number, from raw material lot number to product lot number.

4. Analysis of Results

4.1. Simulation Analysis of Logistics Tracking Information Management System. In the simulation experiment, the number of rings of the network is set to 4, and one of the nodes in each of the three rings is selected for data forwarding to simulate the data collection process of one query. Each node is set with several data sets with a t value of 10 and the query data range of [0, 50] that conform to the data model defined above. Simulations are performed under the prediction-based difference transmission algorithm and without this algorithm, respectively. The energy consumption of node 3 is the most pronounced since it is the innermost node in the loop and it sends both the data it collects and forwards the data from the outer link points. Its life cycle determines the life cycle of the entire network, so attention is paid to node 3. Figure 3 shows a plot of the simulation results for the remaining energy of node 3 regarding the network experience time for one of the data sets. In this data set, the probability of occurrence of the mean value t is roughly 10%.

Figure 4 plots the simulation results for the remaining energy of node 3 concerning the network experience time for another set of data. In this data set, the probability of occurrence of the mean value t is roughly 90%. It can be seen from Figure 4 that node 3 has nearly run out of energy at a network time of 430, and with the prediction-based differential transmission algorithm, the life of node 3 does not end until about 550, extending the network life cycle by nearly 20%, which is a more significant effect than the data in Figure 3. The results of other groups of data runs are not repeated, but the simulation results of each group of data prove that the algorithm is effective; only the discrete probability distribution of the collection object is different than the degree of effect of the network extension time after using the algorithm which is not the same; when $f(t)$ is much larger than the rest of $f(x_i)$, the optimization effect is most obvious.

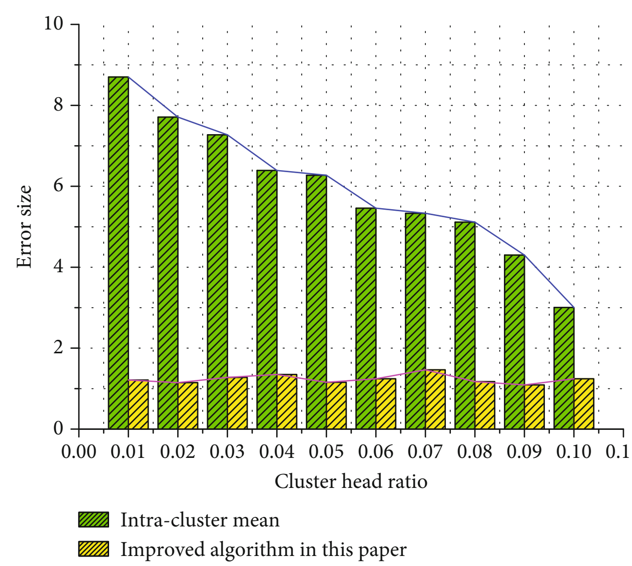

Figure 5: Relationship between error and cluster head ratio.

4.2. Wireless Sensor Network Logistics Tracking Algorithm Analysis. In this experiment, with $N = 4000$, $a = 0.96$, the cluster head ratio p increases gradually from 0.01, in steps of 0.01 to 0.1, and the algorithm comparison results are shown in Figure 5. With the increase of the cluster head ratio p, the data within the cluster that takes the mean value is a sharp decline curve, the average error of this paper's algorithm with the change of the cluster head ratio p only appears a small change, and the error is always smaller than the method of the mean value of the data within the cluster.

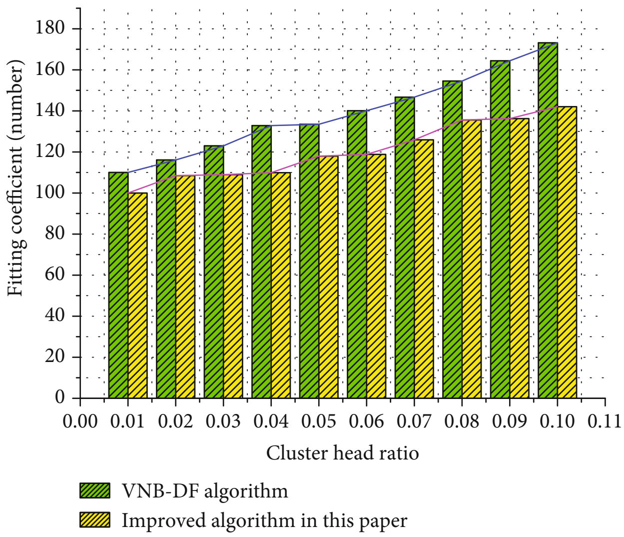

Figure 6: Relationship between the number of fitted coefficients and the proportion of cluster heads.

It can be seen that the algorithm in this paper automatically adjusts the number of fitting coefficients under the premise of ensuring the accuracy of data collection, so the error can always be controlled within a certain range.

The change in the cluster head ratio p affects the number of fit coefficients, which directly represents the amount of data transferred during the execution of the algorithm. The experiment will compare the amount of data transferred by the two algorithms in the same context. The simulation parameters $N = 24000$, $\alpha = 0.96$, and the cluster head ratio p is varied from 0.01 to 0.1 in steps of 0.01, and the experiment is repeated 50 times. As can be seen from Figure 6, the number of coefficients obtained by the algorithm of this paper and the VNB-DF algorithm is a curve curved upward, and the curve obtained by the algorithm of this paper lies below the VNB-DF. When the cluster head ratio p is small, the control range of the cluster is large, the number of sensor nodes in the cluster is large, and the monitoring value of each sensor node has a large difference; to ensure the accuracy requirements, it is necessary to increase the number of fitting polynomials, so that when the cluster head ratio p increases, a smaller number of polynomials can be fitted. The number of fitted coefficients in this paper is smaller than that of the VNB-DF algorithm, which is seen to be better than the VNB-DF algorithm in terms of the amount of transmitted data. Compared with the VNB-DF algorithm, the algorithm in this paper reduces the network communication overhead, saves energy, and extends the survival cycle of the network.

4.3. Logistics Tracking Information Management System Actual Measurement Analysis. The change in the number of packets received from the three nodes by the backend server with time and temperature was tested after a test time of 10 minutes. Figure 7 shows the test results.

From Figure 7, we can see that the frequency of the IRISA node sending packets is constant and does not change with the temperature; the IRISC node is not sending every time; it does not send data when the ambient temperature is less than 30°C, but when the temperature exceeds 30°C. It starts sending packets at the same frequency as the IRISA node; the IRICC node is sending data when the two collected temperature data difference exceeds 5°C before sending data, and when the temperature value is relatively smooth, it does not send data. From the above comparison of the three nodes, we found that the number of packets sent by the IRISB and IRISC nodes is significantly less than that of the IRISA node in the same environment and at the same time. From this, we see that using active logistics status tracking compared to the traditional centralized logistics control approach not only allows processing decisions to be customized as needed but also reduces the pressure on the network and backend servers by avoiding sending redundant data that is of less concern each time. Logistics control using the active state tracking method can effectively reduce the data traffic in the logistics system. While centralized control requires all logistics information to be sent back to the backend server, the autonomous control method can be customized to meet user needs without sending data back to the backend server each time, effectively reducing the pressure on the backend and the network server as the logistics process changes rapidly, while also reducing the energy consumption of wireless sensor nodes and extending the lifetime of the wireless sensor network.

The active state tracking method in this paper should be able to respond to changes in the logistics environment promptly with good responsiveness because it can actively track the state of logistics objects, and, because it is distributed local control, its response speed and performance should be better than centralized ones as the number of nodes increases. To confirm this, the response time of system decision of active state tracking and centralized approach is compared by triggering a large number of data packets in the program logic to simulate the increase of the number of nodes. The response time of the system decision is the time from the completion of collecting logistics information until the completion of decision processing, and the response time of the centralized method is the time from sending packets until receiving the packets for background decision processing; the response time of the active state tracking method is the time from the completion of collecting logistics data until the completion of event processing and decision-making. Figure 8 shows the response time results for the system decision-making.

Figure 8 shows that as the number of nodes increases, the system decision response time of the centralized method increases with it, and the centralized tracking method increases from 40 to 240 with a large increase in response time. In contrast, the response time of the active tracking method does not change significantly with the increase in the number of nodes. This is because the analysis and decision-making of the centralized method are done in the backend server, which requires each node to send the logistics information back to the backend, and then, the backend is unified to process, so with the increase of the number of nodes and the scale of the system, the load pressure on the backend server will be more and more, and its response

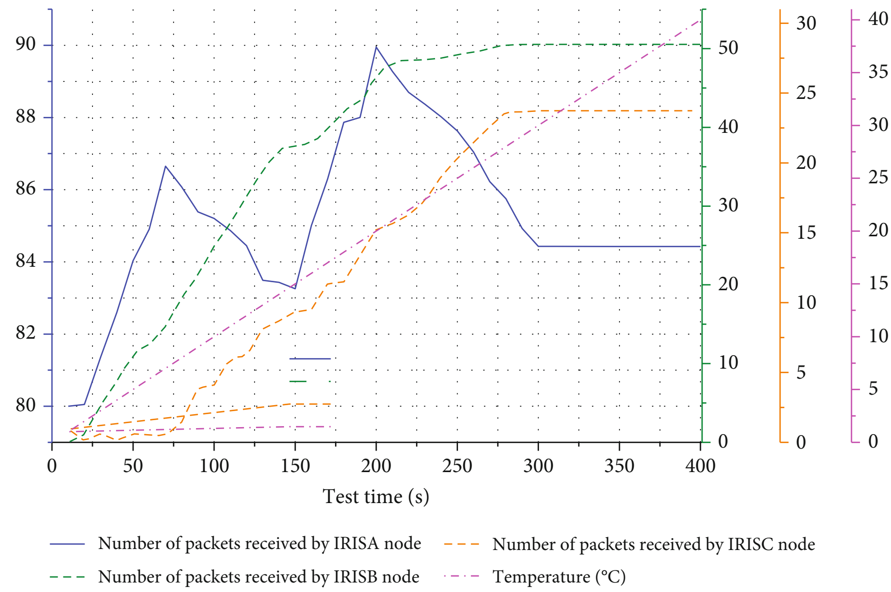

FIGURE 7: Comparison of packets received by the backend server.

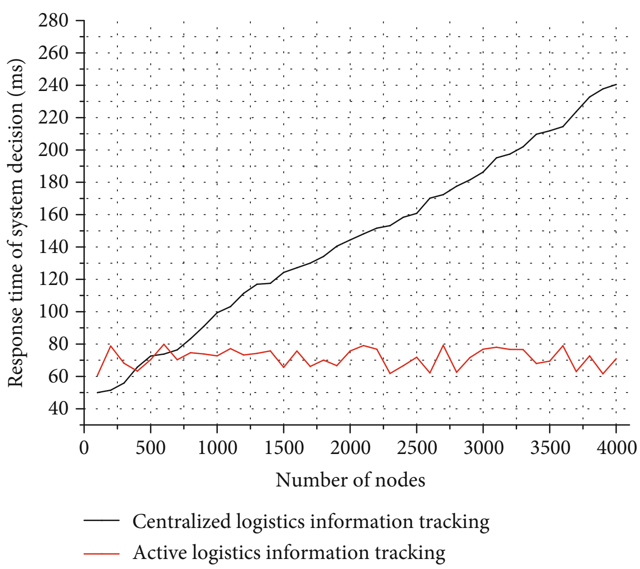

FIGURE 8: Responsiveness of system decisions.

performance will be affected, while the active tracking method is to analyze and make decisions in the wireless sensor nodes, which does not need to send the logistics data to the backend server, thus reducing the load pressure on the network and the backend server, while also improving the response speed of system decision-making and ensuring the real-time processing.

5. Conclusion

With the accelerated pace of informatization of people's lives, the new field of logistics has been developed as never before, and new management technologies have emerged along with logistics cargo transportation, one example being the emergence of logistics tracking information management systems. The monitoring system studied will be widely used once it enters the field of logistics. The system not only provides all-around information on the status of goods in the process of logistics transportation but also greatly reduces the time of logistics managers to trace the status of goods. Because logistics is concerned with the process of goods flow, and the Internet of Things itself is the connection between goods and the Internet in the process of goods flow, so its application in the process of goods flow will be more extensive. The logistics tracking information management system based on wireless sensor network technology is portable, and the system can be useful not only in the process of logistics goods tracking but also in many fields through the modification of the logistics tracking information management object. This paper designs and implements the logistics management system, which is based on a wireless sensor network. The main processes of the three main functional modules (purchasing, inventory, and sales) in the logistics management system are discussed separately, and the functional requirements of the system are described in detail so that the system achieves authentication and operates on the data layer in terms of business logic for the stored processes. In this paper, wireless sensor networks are used for the management of logistics tracking information. But for vehicles, there is other working condition information in the process of operation. With the continuous improvement of the system, other working condition information is to be managed. Information technologies applied to the platform design such as block chain technology and NB-IOT technology are emerging technologies at present, but the use of these technologies is also in the initial stage, and the value of these technologies will be developed and applied more and more deeply in the future. As technology progresses and develops, the platform framework model and system construction will be further improved, the research on the platform will be further deepened, and there is still much room for the platform to be improved in the future.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of 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.

References

[1] Q. Gao, S. Guo, X. Liu, G. Manogaran, N. Chilamkurti, and S. Kadry, "Simulation analysis of supply chain risk management system based on IoT information platform," *Enterprise Information Systems*, vol. 14, no. 9-10, pp. 1354–1378, 2020.

[2] C. Zhou and Q. Cao, "Design and implementation of intelligent manufacturing project management system based on bill of material," *Cluster Computing*, vol. 22, no. S4, pp. 8647–8655, 2019.

[3] C. K. M. Lee, Y. Lv, K. K. H. Ng, W. Ho, and K. L. Choy, "Design and application of internet of things-based warehouse management system for smart logistics," *International Journal of Production Research*, vol. 56, no. 8, pp. 2753–2768, 2018.

[4] Y. Ding, M. Jin, S. Li, and D. Feng, "Smart logistics based on the internet of things technology: an overview," *International Journal of Logistics Research and Applications*, vol. 24, no. 4, pp. 323–345, 2021.

[5] L. Deng, D. Li, X. Yao, and H. Wang, "Retracted article: Mobile network intrusion detection for IoT system based on transfer learning algorithm," *Cluster Computing*, vol. 22, no. S4, pp. 9889–9904, 2019.

[6] C. Worlu, A. A. Jamal, and N. A. Mahiddin, "Wireless sensor networks, internet of things, and their challenges," *International Journal of Innovative Technology and Exploring Engineering*, vol. 8, no. 12S2, pp. 556–566, 2019.

[7] B. Sharma and D. Koundal, "Cattle health monitoring system using wireless sensor network: a survey from innovation perspective," *IET Wireless Sensor Systems*, vol. 8, no. 4, pp. 143–151, 2018.

[8] R. Cheour, S. Khriji, D. El Houssaini, M. Baklouti, M. Abid, and O. Kanoun, "Recent trends of fpga used for low-power wireless sensor network," *IEEE Aerospace and Electronic Systems Magazine*, vol. 34, no. 10, pp. 28–38, 2019.

[9] P. Singh, A. Khosla, A. Kumar, and M. Khosla, "Computational intelligence based localization of moving target nodes using single anchor node in wireless sensor networks," *Telecommunication Systems*, vol. 69, no. 3, pp. 397–411, 2018.

[10] A. Thakur and R. Malekian, "Fog computing for detecting vehicular congestion, an internet of vehicles based approach: a review," *IEEE Intelligent Transportation Systems Magazine*, vol. 11, no. 2, pp. 8–16, 2019.

[11] R. Kingsy Grace and S. Manju, "A comprehensive review of wireless sensor networks based air pollution monitoring systems," *Wireless Personal Communications*, vol. 108, no. 4, pp. 2499–2515, 2019.

[12] H. N. Dai, H. Wang, G. Xu, J. Wan, and M. Imran, "Big data analytics for manufacturing internet of things: opportunities, challenges and enabling technologies," *Enterprise Information Systems*, vol. 14, no. 9-10, pp. 1279–1303, 2020.

[13] X. Fang and L. Chen, "Noise-aware manoeuvring target tracking algorithm in wireless sensor networks by a novel adaptive cubature Kalman filter," *IET Radar, Sonar & Navigation*, vol. 14, no. 11, pp. 1795–1802, 2020.

[14] C. Liu, Y. Zhou, Y. Cen, and D. Lin, "Integrated application in intelligent production and logistics management: technical architectures concepts and business model analyses for the customised facial masks manufacturing," *International Journal of Computer Integrated Manufacturing*, vol. 32, no. 4-5, pp. 522–532, 2019.

[15] W. Osamy, A. M. Khedr, and A. Salim, "ADSDA: adaptive distributed service discovery algorithm for internet of things based mobile wireless sensor networks," *IEEE Sensors Journal*, vol. 19, no. 22, pp. 10869–10880, 2019.

[16] V. Damjanovic-Behrendt and W. Behrendt, "An open source approach to the design and implementation of digital twins for smart manufacturing," *International Journal of Computer Integrated Manufacturing*, vol. 32, no. 4-5, pp. 366–384, 2019.

[17] K. T. Park, Y. W. Nam, H. S. Lee et al., "Design and implementation of a digital twin application for a connected micro smart factory," *International Journal of Computer Integrated Manufacturing*, vol. 32, no. 6, pp. 596–614, 2019.

[18] A. Sungheetha and D. R. Sharma R, "Real time monitoring and fire detection using internet of things and cloud based drones," *Journal of Soft Computing Paradigm*, vol. 2, no. 3, pp. 168–174, 2020.

[19] E. Baraneetharan, "Role of machine learning algorithms intrusion detection in WSNs: a survey," *Journal of Information Technology*, vol. 2, no. 3, pp. 161–173, 2020.

[20] X. Zhu, "Complex event detection for commodity distribution internet of things model incorporating radio frequency identification and wireless sensor network," *Future Generation Computer Systems*, vol. 125, pp. 100–111, 2021.

[21] A. M. Manoharan and M. G. Sumithra, "Secure data communication IoT and wireless sensor network for COVID-19," *International Journal of Sensor Networks*, vol. 36, no. 1, pp. 11–24, 2021.