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# Design of Intelligent Warehouse Management System

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**Abstract** With the continuous development and application of information technology in the logistics industry, mobile applications, bar code, wireless communication, system integration and other technologies are widely used in warehouse management. Focusing on warehousing process management has become a new trend of informatization and lean management of material warehouse management. In this paper, the management of distributed storage cloud model is discussed, and a variety of automation, intelligence and information technology are utilized to effectively integrate the resources effectively. The author studies the resource scheduling optimization problem in the system, proposes an effective scheduling method, and initially realizes the intelligent warehouse management system based on cloud model, which provides users with a good package management service.

**Keywords** Intelligent warehouse · Management system · Model

## 1 Introduction

The development of modern logistics industry needs the support of information technology [1]. Information technology makes the information system run through different enterprises, which greatly improves the efficiency of logistics. At the same time, it also provides the conditions for the integration of enterprise demand, distribution and inventory management. Logistics informatization can be applied to every link of the logistics process, which can be used for systematic control of a single link, such as transportation, storage and procurement, and can also be applied to the whole logistics process. Overall, logistics

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information is the use of modern information technology in the entire process of logistics information collection, identification, classification, aggregation, transmission, sharing, tracking and query. It can realize the effective communication and seamless connection of the supply, demand, storage and transportation of materials, and construct a logistics supply chain with both high speed and high efficiency and low cost advantage [2]. Therefore, the development of information technology has become the inevitable requirement of the development of the logistics industry, and the progress of information technology helps to improve the efficiency and quality of logistics delivery.

## 2 State of the Art

At present, in some large and medium-sized logistics companies with relatively high level of informatization, E-commerce platform based on enterprise website are rare. Most of the function of enterprise website are to promote the corporate image [3]. In addition, some of the logistics warehousing information system has been completed. Its functions generally include order management, warehousing management, financial management and transportation management, but there are few achievements in the construction of warehouse logistics network information [4]. In this context, many scholars have studied warehouse management system. Studies have pointed out that the problems in the development of the warehouse management system is mainly embodied in the following aspects: First, the scale of warehouse resources in our country is large, but most of the warehouse management functions are not perfect, and the degree of information is low, resulting in low logistics efficiency and increased inventory costs year by year. Second, enterprises do not pay enough attention to warehouse management. They believe that warehouse information cannot bring direct economic sources for enterprises, and it is not very helpful to improve the efficiency of enterprises, so they are reluctant to invest in warehousing information management [5]. Third, even if some enterprises build warehouse management system, due to the ambiguity of the previous design ideas and the failure of the management system, the warehouse management system has not reduced the workload of the warehouse management personnel, but it has caused the tedious and complicated steps of the document input [6]. The warehouse manager produced resistance to the system, leading to serious abandoned system. Fourth, it lacks support from policies and regulations. At present, logistics warehousing management, construction standards, and the market order is not perfect. There is no complete warehouse management laws and regulations for the logistics industry to restrict the industry order [7].

## 3 Methodology

### 3.1 System Architecture

The structure of the intelligent warehouse management system is shown in Fig. 1, which is mainly composed of mobile terminal system, application processing center, centralized printing application layer and wireless network environment [8].

The application processing center is the nerve center of the intelligent warehouse management system, which is responsible for connecting the ERP system and the mobile terminal processing system [9]. The mobile terminal (PDA, PAD) obtains the source data

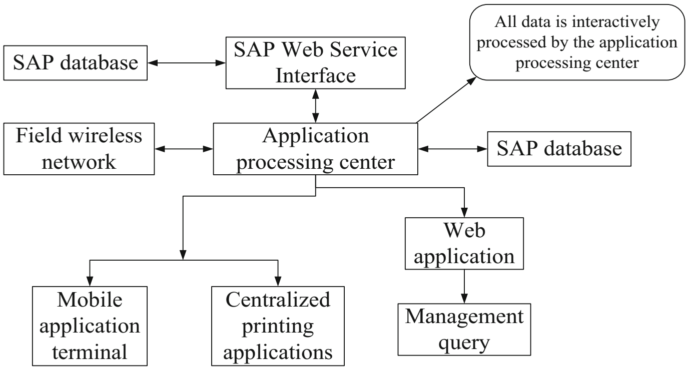


**Fig. 1** Application structure of intelligent warehouse management system

from the ERP database in real time through the ERPWeb Service interface in the wireless network environment. In the intelligent warehouse management system, data processing center is used for data collation. According to different business requirements, the intelligent warehouse management system designs three subsystems, namely PDA subsystem, PAD subsystem and PC subsystem [10].

## 3.2 Interface Mode

The third party warehouse management system interacts with the ERP system through the interface, and there are four kinds of interface technology implementations. Write the WMS temporary table, that is, ERP submits the document concurrently or delays writing the WMS temporary table, this way provides temporary table by WMS. Tune WMS's Web Service, that is, ERP also submitted documents or delayed call WMS Web Service to synchronize data to WMS. This method provides Web Service with WMS, and ERP synchronously submits data to WMS by submitting or delaying the call of Web Service. Read ERP temporary table, that is, temporary tables are provided by ERP. ERP writes temporary tables of ERP while submitting documents. WMS accesses ERP temporary tables at regular intervals, and synchronize data to WMS database. Tune ERP's Web Service, that is, ERP provides Web Service. When ERP submits a document, the data is temporarily stored in the temporary table, and the WMS calls Web Service to query data from the temporary table and synchronize the data to the WMS.

The above four interface methods have advantages and disadvantages: The temporary table of the third party system can realize the real-time synchronization of data, but both the ERP and the third party system do not stop accessing the temporary table, which easily causes the resource shortage of the third party system server and leads to the operation fault. At the same time, both systems in the temporary table work are difficult to distinguish the responsible party. The method of calling the third party system Web Service is simple, and the ERP side development work is small. However, due to the influence of network environment and the operation of the third party server, when the documents are not submitted promptly, the real time data cannot be guaranteed. The way to read the temporary table of ERP system has the advantages of simple implementation and small workload of ERP side development. However, it is difficult to distinguish the responsibility of the third party system when the system problem occurs. The way of adjusting ERP system Web Service: the two systems are separated from each other, which is easy to distinguish responsibility, but it is affected by ERP fault, server, network and other issues, resulting in that ERP data cannot be timely synchronization to the risk of the third party system. Interface technology differences are detailed in Tables 1 and 2.

### 3.3 Scheduling Algorithm Design

For scheduling algorithm design, we first initialize the population, set the population size of popsize, and randomly generate the initial population. Unrestricted random population may lead to infinite iterations of the algorithm, and it can't converge. According to the initial conditions given by the scheduling problem and the constraints that the solution of the problem should satisfy, each scheme is initialized and repeated several times to obtain the initialized population. The main constraint conditions of each scheme encoding $m \times p$ matrix are the value of each column and quantity demanded of the material. The initialization of each scheme follows the following algorithm:

First, we iterate the column number j to initialize the supply of each kind of material to each warehouse. The variable tempBi temporarily records the amount of Kj material stored in the warehouse Si, and its initial value is the Bij value in the formula (3–6). The variable tempQ is the current demand of the Kj material, and the initial value is the value of Qj in the formula $(3-1)$, and the value will gradually decrease to 0. tempGi temporarily stores the supply of Kj from storage Si. When tempQ $>$ 0, that is, the warehousing supply has not yet met the demand, performs the random allocation operation. Randomly select a warehouse Si, if its current material storage capacity of tempBi is greater than 0, it supplies part of the material, and then it performs the next step, otherwise it returns and picks up the warehouse. If tempQ $=$ 0, execute the next step directly. TempBi $>$ 0, generates Si of goods in warehouse temp_rand, but satisfies the constraints. At this point, the temp_rand is accumulated into the tempGi, modifying the values in the tempQ, subtracting the temp_rand. Then, we go back to step 2 to determine the value of tempQ. If tempQ $=$ 0, the demand for current supplies have been allocated. We return step 1 to initialize the supply of the next material until all the goods are fully allocated to each warehouse and the scheme is initialized.

The fitness function is used to evaluate the advantages and disadvantages of each scheme in the population, which is the basis for the selection. In this scheduling problem, the fitness function is designed based on the optimized target in the above. That is, the storage resource utilization rate, the numbers of warehouses involved in scheduling and scheduling time are considered to comprehensively evaluate the fitness of the program. The fitness function f is shown in Eq. (1).

$$f = \frac{\sum_{i=1}^{m}\left(F_i \times \sum_{j=1}^{p}\frac{x_{ij}}{B_{ij}}\right)}{w_1 \times \varsigma_1 \times \sum_{i=1}^{m}F_i + w_2 \times \max\{F_i \times t_i\}} \times \varsigma_2 \tag{1}$$

The parameter $F_i$ is utilized to eliminate storage that not involved in scheduling. $\frac{x_{ij}}{B_{ij}}$ indicates the percentage of $K_j$ material supplied by warehousing $S_i$ as a percentage of its supply. It reflects the degree of utilization of storage resources, and $\sum_{j=1}^{p}\frac{x_{ij}}{B_{ij}}$ is the comprehensive evaluation of warehouse. All the participating warehouses are evaluated, and all the material calls in the scheduling scheme are evaluated. Here, $\varsigma_2$ corrects the results on the whole. The higher the utilization ratio of warehouse resources, the higher the fitness, the smaller the number of storage and scheduling time the denominator represents, the higher the fitness. Therefore, the value of fitness function f is greater, indicating that the

**Table 1** Interface technology difference comparison

| The interface way | Impact on production systems | The coupling of the two systems | The real time | The third party system is subject to the fault of the interface | The ERP system is subject to the fault of the interface | Impact on ERP submission data | Development tools of ERP interface |
|---|---|---|---|---|---|---|---|
| Write a temporary list of third-party systems | Higher | High | High | Hard | – | Higher | Bigger |
| Tune the third-party system Web Service | The minimum | Low | High | Easy | – | Lower | The minimum |
| Read the ERP system temporary table | Maxima | High | Low | – | Hard | The minimum | Smaller |
| Tune ERP system Web Service | Lower | Low | Low | – | Easy | Lower | Bigger |

Table 2 Interface technology difference comparison

| The way | Advantage | Disadvantages |
|---|---|---|
| Mode 1 way to write a third-party system temporary table | Such as ERP submission of documents and at the same time the data is written to a third-party system temporary table, enabling real-time data synchronization | When the third-party system failure is difficult to distinguish between responsibilities. As the temporary table is a shared table, ERP system needs to write data to a third-party system temporary table. In order to ensure real-time synchronization of data, third-party systems need to keep access to the temporary table. When the third-party system server fails, you need to analyze the two programs to determine the problem. However, in fact, the procedures of the two sides are independent and the analysis of the problems is difficult to operate and difficult to distinguish<br>Synchronously when the ERP submits the document, if the third party system fails or the server or the network fail to call, the normal submission of the documents on the ERP side will be affected<br>If the ERP side of the document does not immediately call the Web Service, but through the timing of the delayed call Web Service trigger, although the impact does not affect the ERP side of the submission of documents. However, the data of the ERP can not be synchronized with the third-party system in real time, which may cause the third-party system to interrupt the business operation due to the inability to obtain the proper data, thereby affecting the production<br>Due to changes in demand and other reasons need to change the structure of the temporary table, the interface program needs to be modified, will have additional development costs<br>ERP submission documents processing speed slower than before |

**Table 2** continued

| The way | Advantage | Disadvantages |
|---|---|---|
| Mode 2 transfer third-party system Web Service | To achieve a simple, ERP-side development workload.<br>Such as ERP documents submitted at the same time call Web Service.<br>The two systems separated by the Web Service interface, mutual influence, easy to distinguish between responsibilities.<br>The design of a flexible Web Service interface to deal with future changes in the interface changes caused by additional program development | If the third party system Web Service is called synchronously when the ERP submits the document, if the third party system fails or the server or the network fail to call, the normal submission of the documents on the ERP side will be affected<br>If the ERP side of the document does not immediately call the Web Service, but through the timing of the delayed call Web Service trigger, although the impact does not affect the ERP side of the submission of documents. However, the data of the ERP can not be synchronized with the third-party system in real time, which may cause the third-party system to interrupt the business operation due to the inability to obtain the proper data, thereby affecting the production<br>ERP submission documents processing speed slower than before |
| Mode 3 read the temporary table of ERP | To achieve a simple, ERP-side development workload.<br>ERP documents submitted at the same time need to write data into the temporary table, but due to the temporary table in the ERP system itself in the same system, so the speed has little effect | When the third-party system failure is difficult to distinguish between responsibilities. As the temporary table is a shared table, ERP system needs to write data to a third-party system temporary table. In order to ensure real-time synchronization of data, third-party systems need to keep access to the temporary table. When the third-party system server fails, you need to analyze the two programs to determine the problem. However, in fact, the procedures of the two sides are independent and the analysis of the problems is difficult to operate and difficult to distinguish<br>If the ERP side of the document does not immediately call the Web Service, but through the timing of the delayed call Web Service trigger, although the impact does not affect the ERP side of the submission of documents. However, the data of the ERP can not be synchronized with the third-party system in real time, which may cause the third-party system to interrupt the business operation due to the inability to obtain the proper data, thereby affecting the production<br>Due to changes in requirements and other reasons need to change the temporary table structure, the interface program needs to be modified, will have additional development costs |

**Table 2** continued

| The way | Advantage | Disadvantages |
|---|---|---|
| Mode 4 tune ERP Web Service | The two systems separated by the Web Service interface, mutual influence, easy to distinguish between responsibilities.<br>The design of a flexible Web Service interface to deal with future changes in the interface changes caused by additional program development.<br>Do not pass bi-directional log records to check the specific interface call process | When the third-party system failure is difficult to distinguish between responsibilities. As the temporary table is a shared table, ERP system needs to write data to a third-party system temporary table. In order to ensure real-time synchronization of data, third-party systems need to keep access to the temporary table. When the third-party system server fails, you need to analyze the two programs to determine the problem. However, in fact, the procedures of the two sides are independent and the analysis of the problems is difficult to operate and difficult to distinguish<br>Call ERP Web Service, resulting in third-party system can not be real-time access to ERP system data, it may lead to third-party systems due to lack of access to the data and interrupt business operations, and thus affect the production |

fitness of the scheme is higher. The fitness function value fitvalue of each scheme in the population is used as the basis for the selection in subsequent operations.

In view of the previous cloud storage logistics scheduling model, this section will apply a bee colony genetic hybrid optimization scheduling algorithm to optimize the solution and search for the best solution. Aiming at the specific problems, the author designs the selection operator, crossover operator and mutation operator in the algorithm, and gets the best fitness solution after generations of propagation optimization.

# 4 Result Analysis and Discussion

## 4.1 System Function Test

Logistics management module achieves the logistics tracking, logistics information management, logistics management. The functions of the three parts are tested, and the performance of the hybrid genetic algorithm is simulated and analyzed. For logistics tracking, delivery list of specific odd number is located and queried by GPS. The electronic map matches its current location, and displays the outgoing number, vehicle number plate, location, shipping warehouse and other information. For the logistics information management part, it displays the detailed list in the management scope. When click any specific outbound list, you will enter the specific operation page. In the logistics information management detailed operation page, it displays the basic information and detailed list of materials. The shipper will confirm the quantity of each item by manual input of actual quantity and material confirmation, and then click to confirm receipt after confirmation by item. At this point, the system will make a corresponding judgment, if the number of the library and the actual number of receiving does not match, the document needs to be further processed, and the logistics information management list will continue to retain the document. If the number of the displayed quantities is consistent with the actual number of received goods, the receipt will be successful, and the document will be removed from the logistics information management list. Due to the limited space, we will not repeat the test of other items.

The logistics scheduling management module uses the bee colony genetic hybrid optimization scheduling algorithm described in the previous paper. Firstly, the simulation of the optimal scheduling algorithm is carried out, and its performance is analyzed. The initial conditions of the algorithm are set up, in which the storage quantity is $m = 6$, the demand material type is $p = 5$, the storage and storage time of each warehouse and the delivery time are shown in Table 3. The material requirements for scheduling are shown in Table 4. Population size is popsize = 100, genetic algebra is limited to num-generation = 50, cross probability is Pc = 0.6, variation probability is Pm = 0.001. In the fitness function, $w_1 = 0.6$, $w_2 = 0.4$, $\xi_1 = 10$, $\xi_1 = 100$.

The simulation analysis of performance optimization scheduling algorithm for mixed bee swarm genetic below is proposed in this paper. In the initial conditions, it performs optimal scheduling algorithm. The fitness function values of each generation scheme in the genetic process are recorded, and the maximum fitness value, the average fitness value of the top 10 and the mean value of fitness values for all schemes are marked. As shown in Fig. 2.

The abscissa in the graph represents the algebra of heredity, and the maximum value of the fitness in the population is marked by the vertical starting point from the curve to the height (marked by number 1). The mean value of the first 10 maximum fitness values in the

**Table 3** Warehouse basic data

| | Material types | | | | | Delivery time |
|---|---|---|---|---|---|---|
| | $K_1$ | $K_2$ | $K_3$ | $K_4$ | $K_5$ | T |
| Warehousing $S_1$ | 1300 | 200 | 60 | 3000 | 1200 | 20 |
| Warehousing $S_2$ | 1500 | 310 | 40 | 2000 | 1600 | 30 |
| Warehousing $S_3$ | 600 | 200 | 30 | 1000 | 600 | 50 |
| Warehousing $S_4$ | 800 | 500 | 20 | 1800 | 500 | 25 |
| Warehousing $S_5$ | 900 | 150 | 50 | 800 | 1400 | 40 |
| Warehousing $S_6$ | 2200 | 200 | 10 | 200 | 800 | 35 |

**Table 4** Material demand data

| | Material types | | | | |
|---|---|---|---|---|---|
| | $K_1$ | $K_2$ | $K_3$ | $K_4$ | $K_5$ |
| Quantity demanded | 2000 | 300 | 50 | 4200 | 1600 |

population is marked as number 2, and the average fitness value of all the alternatives in the population is marked as number 3. According to the graph analysis, the starting points of the three curves are different. Especially, the starting points of curve 1 and curve 3 are quite different, which shows that the initialization population generated by the algorithm has certain randomness. With the running algorithm of generations, the difference between the three curves is getting smaller, and all of them are on the rise, and eventually converge to the same value, which shows that the algorithm does optimize the scheme of the population in the process of operation, which has a certain convergence.

The algorithm is run 100 times under the above initial conditions, and the optimal fitness value of each program is recorded, and the curve is plotted, as shown in Fig. 3. According to the graph, the best fitness values obtained by the running algorithm are slightly different under the same initial conditions, which are related to the setting of some random parameters in the algorithm. But the running results of the best fitness value are

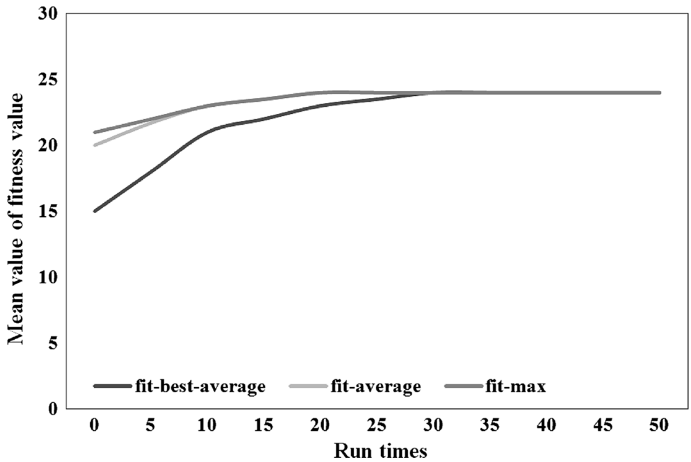


**Fig. 2** The fitness of each generation of the algorithm and its mean curve were compared

concentrated in the range of 2226, the fluctuation range is not large, and the algorithm has certain stability.

The optimal scheduling algorithm combines the domain search in bee colony algorithm with the improved genetic algorithm. In this paper, the final algorithm is compared with the original genetic algorithm, the improved genetic algorithm, and the bee colony algorithm. With the same initial conditions mentioned in the front, through the fitness performance curve of original genetic algorithm, improved genetic algorithm, bee colony algorithm, and bee colony genetic hybrid optimization scheduling algorithm with neighborhood search, we can know that the convergence of genetic algorithm is relatively fast. Bee algorithm is slower than the genetic algorithm, but it can get better solution. Compared with the other three algorithms, the optimal scheduling algorithm proposed in this paper has a slower overall convergence, but it can find the relatively optimal solution. The four algorithms are run 100 times under the same initial conditions, and the optimal fitness values are obtained at each run. The minimum, mean, and maximum values of the best fitness value of the corresponding algorithm in the 100 run are calculated, and the results are plotted. In the 100 run, the minimum fitness, the average value and the maximum fitness of the optimal scheduling algorithm proposed in this paper are better than the other three algorithms.

Under different population size popsize, the four algorithms are compared with each other. The population size is set to 20, 50 and 100 respectively. The genetic algorithm, the improved genetic algorithm, the bee colony algorithm, and the optimized scheduling algorithm curve are proposed. We can conclude that the larger the population size, the better the fitness that can be reached. This is because the larger the population size, the more alternatives. So the program is more diverse, which is easier to get better programs. At the same time, the optimal scheduling algorithm proposed in this paper can be better than the other three algorithms in different population size. The bee colony genetic hybrid optimization scheduling algorithm is applied to the logistics scheduling management module of the system. In the system, there is a list of statistical requirements for each requirement. Enter the specified demand odd number into the system, and click the dispatch allocation button, the system calls the optimization algorithm to search data in the related data table. The schedule of the requirements list is feedback by the page.

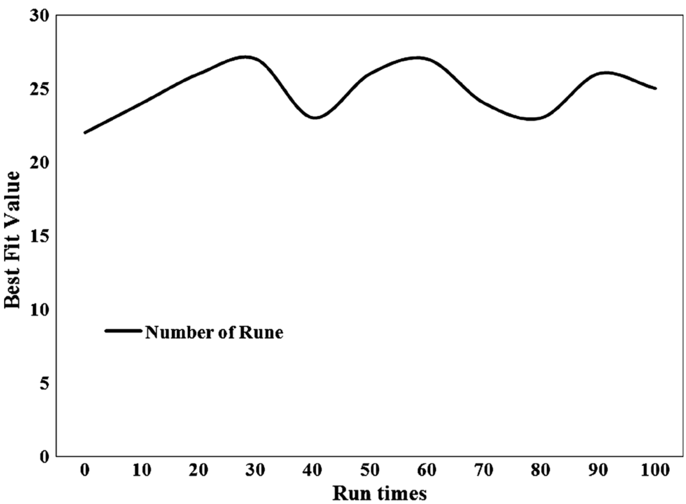


**Fig. 3** The optimal fitness curve of the algorithm is given

In this chapter, the main functional modules of the system, namely warehouse management module and logistics management module and its sub modules, are run and tested to verify the functions provided by each part. The simulation of bee colony genetic hybrid optimization scheduling algorithm is carried out, and it is proved that although the convergence is slow, it is beneficial to get better scheduling solution, which has certain robustness.

## 5 Conclusion

One of the most important things in logistics operations is the transit of goods from finished goods to use. Since it is a transit, there must be a storage process in the middle, which involves the management of materials in the storage, that is, the problem of warehouse management. In this paper, the function framework of intelligent warehouse management system based on cloud model is designed, and a hybrid genetic algorithm based on bee colony is proposed to solve the problem of cloud storage logistics scheduling. The system makes use of the RFID technology and GPS technology to obtain real-time data. The intelligent warehouse management system is built to provide users with the two main parts of warehouse management and logistics management services, and realize the intelligent monitoring and management of the entire storage life cycle of materials. In this paper, the cloud storage logistics resource scheduling problem is modeled under the actual environment, and the evaluation index system of logistics resource scheduling is constructed. Combined with the real time perception information of warehouse and the key factors affecting logistics scheduling, this paper studies the scheduling evaluation and decision-making of logistics resources in the cloud storage environment, and proposes an optimal scheduling method. Finally, we run and test the main functional modules of the system, and make simulation analysis. The test results show that although the convergence of the algorithm in the system is slow, but it is conducive to get better scheduling solution, which has certain robustness.

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