The Research on Improving the Order Picking Efficiency in Medical Logistics Area of CPL Based on Serial Partition Relay Picking Model

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Abstract

The medical business of China Post Logistics is developing day by day. China Post Logistics have been using the Parallel partition picking mode for a long time, but too many shortages have appearing in these two years, especially in the order picking cost and efficiency. This paper analyzes the current order picking mode of China Post Logistics and compare with the Parallel partition picking mode. By analysis the advantages and disadvantages of these two modes and combine with the actual situation, we choose the serial partition relay picking model as the picking mode of CPL in medical logistics area. And then it optimizes the order picking route in view of the current deficiency combined with the use of Ant Colony Optimization (ACO). The example simulation result shows that this optimizing is effective and the order picking cost decrease 17.36% and the route decrease 9.80% than that as before. This research not only to Chain Post Logistics but also to other logistics company which runs the medical business has certain reference.

Keywords: *China Post Logistics; Medical Logistics; Serial Partition Relay Picking; Ant Colony Optimization*

1. Introduction

Medical logistics has a big difference with other industry logistics, and it has complex classifications, too much emergency distribution request and so on. It is the second difficulty industry only to the automotive industry logistics [1]. In the warehousing field, it is very complicated due to the multi-vendor, multi-volume, small batches of mixing operations and the special characters of the drugs. In general, a large pharmaceutical warehouse usually divided into several libraries, such as fragmented library, acceptance library, and to be transported library in the base of the business standard. And at the same time, it will be dived into normal temperature, cool library, and easy odor libraries in the base of the GSP standard.

The INFOR system has been the Supply Chain Execution system for China Post Logistics by the tender selections since 2010. The implementation of this system has dealt with most of the problem that China Post Logistics met in its warehousing part of medical business area. Even thought, there are still many disadvantages, such as the high cost of its order picking and lower efficiency of its order picking. These disadvantages reduce the efficiency of China Post Logistics' operations, and it hindering the development of this field in China Post Logistics. It is very urgent for China Post Logistics to optimize the warehousing efficiency. In the base of these, this paper put up relevant remedies (replace the parallel partitions Relay picking mode with serial partition Relay picking mode) after analyzing the current order picking situation and comparing the two modes. At the end of this paper, it planned the order picking route under the serial partition Relay picking mode by the means of Ant Colony System, and draw some relevant conclusions.

2. The outline of parallel partition picking mode

Order sorting is a process which do as quick as possible and as accurately as possible to pick out the goods from the shore, classification in a certain way and waiting for compatibility as the customers' and the distribution's order. Order picking routing is to determine the sorting list of goods from picking orders through the heuristic optimization to reduce the order pickers' walking distance. There are lots of studies show that the order pickers' walking time account for about 50% of the total order time, so it is very important to reduce the order pickers' walking time.

Currently, order picking mode in the field of Medicine of China Post Logistics is parallel partition relay picking mode. Parallel partition relay picking refers to the process in which all the goods were chosen gradually. After finished picking goods from all regions, the pickers

transferred containers (boxes or pallets) that were full of all kinds of items to the nest partition or handed them over to the next picker who was responsible for his partition. This picker was responsible for sorting all the goods in this partition. The whole order sorting job wasn't completed until the last picker finished his job. Just like the assembly line in manufacturing factory, the following process can start only if the previous process is finished. The product was completed when the last process was finished [2, 3]. The specific operational processes of the picking mode is shown in Fig 1.

In Fig 1 the solid box represents every storage area in the warehouse, usually storage area is closed. Bar graph in solid box indicates storage cargo space of drugs In this mode, a picker is not responsible for the completion of picking a full order, and all items in one order are selected from different regions. Therefore, these items are selected by different pickers, and then were sent to the final tally by belt [2].

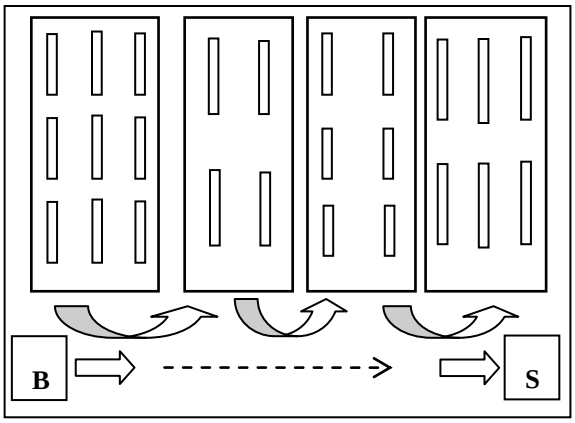

Fig.1 Schematic diagram of parallel partition relay picking mode

In this mode, each picker was assigned to the named shop or zone, and they will be very familiar with the items and its locations in their sorting regions, which can improve the efficiency and accuracy of sorting jobs. At the same time, there is no more than one picker in one corridor, which can avoid the congestion to the maximum extent. In this mode, Pickers have little or no chance to chat with other staff because of the regional segmentation which is helpful for warehouse managers to control and supervise the staff.

However, in the chosen mode, the previous partition pickers did not complete the order picking when the following partition picker was back to the junction points. This picker cannot help the previous pickier to sort the items by crossing the junction point(will not take the initiative to help the former pickers) At this point, the picker will choose to wait which will result in a waste of time .This order picking efficiency cannot be achieved the highest [3-4]. In this mode, the system needs to analysis the orders or arranges the staff, which in some extent increases the warehousing cost of China Post logistics. And, when the order volume is not up to a certain quantity, each partition requires at least one picker, which tremendous waste warehouse labor costs particularly in high labor costs society.

3. Serial partition relay picking mode

3.1 Overview of serial partition relay picking mode

Serial partition relay picking model is an improved model of parallel partition relay picking model. The specific operation of this mode is shown in Fig 2.

In this mode, the order is not spitted, so the pickers sort the items from one picking area to one picking area. After finishing the sorting job in this picking area, the pickers transferred the containers (boxes or pallets) to the next picking area to continue sorting. The whole order sorting job wasn't completed until the last item in this order was sorted. In this mode, because each picker is responsible for one or several orders and orders are not divided. This picking model can greatly improve the response speed of the order, and also can eliminate cost to classify the orders [5], which is particularly important for responding emergency orders in medical logistics field in the China Post Logistics

Compared to with parallel partition relay picking mode, serial partition relay picking mode has the following four advantages:

1) Fast reaction speed of orders. This is the biggest advantage of serial partition relay picking mode, especially for frequent emergency orders ordered by customers in pharmaceutical warehousing field in China Post Logistics. In the serial partition relay picking mode, each picker is responsible for a complete order, pickers can quickly deal with the orders. It is easier to get overstock in parallel partition relay picking mode, which reduces the speed of response to the orders. In China Post medicine field, we often receive a large number of emergency orders, thus the reaction speed to order of is particularly important.

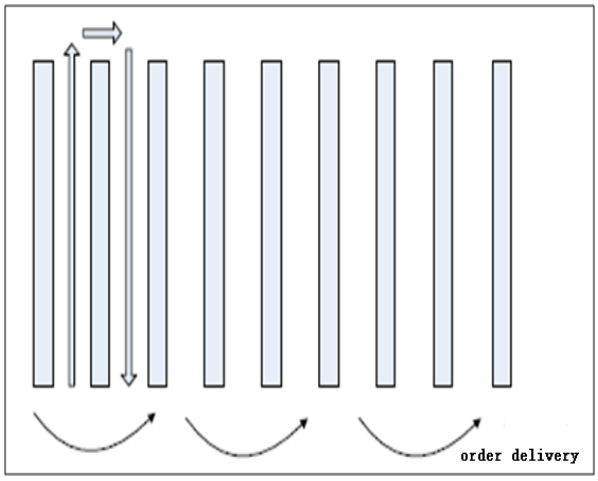

Fig.2 Schematic diagram of Serial partition relay picking mode

2) Reduced cost of labor. In the serial partition relay picking mode each storage area doesn't require one pickers. One picker sorts all the items in one order. It is goods for pharmaceutical warehouse of China Post who has a large number of different sorting areas especially in the case that the human cost is very expensive.
3) Reduced cost of order classification. In parallel partitions relay picking mode, it requires to split each order firstly, which requires a single system or machine to split the orders. This is actually a waste of behavior. However, it does not need to split orders, which save the cost of order classification.
4) High accuracy of selection. In this mode, each picker is responsible for the entire order, which makes pickers clear of the location of cargo in order not to cause the omission. Goods from different orders in one picking area are required to be reallocated according to the order after sorting which makes the low accuracy of order picking in the serial partition relay picking mode
Of course, the serial partition relay picking mode has some shortcomings, specifically the following 2 points:
1) Congestion in warehouse channel. This is more important for warehouse with higher degree of mechanization operation, but less important for warehouse with generally degree of mechanization operation. The degree of mechanization operation in the field of China Post Logistics is not very high, so it will not cause congestion
2) Meaningless exchanges between employees. In the serial partition relay picking mode, because there are a large number of the intersection between different pickers , it makes an increase in unnecessary exchanges between the pickers , which wastes the sorting time and reduces the efficiency of the order picking.
There are a large number of emergency orders in medical logistics warehousing chosen field in China Post Logistics. These orders need short time to reaction, and there is not expensive sorting equipment in the field of postal logistics warehouse which basically needs human to sort. Based the two above aspects as well as the advantages and disadvantages of the above serial partition relay picking mode with parallel partition relay picking model, this paper selects the serial partition relay picking mode to enhance the efficiency of warehouse order picking in China Post Logistics in the field in order to be able to improve the efficiency of the supply chain execution system in the areas.

3.2 The key to optimize the serial partition relay picking model

The biggest advantage of China Post Logistics' medical warehousing field is the time saving. Therefore, save as much time as possible is very important, especially for China Post Logistics which have a lot of urgent orders. The customers in nowadays consider the order speed more and more, how to response the order as quick as possible becomes more and more important.
There is a research found that the time savings from two main parts in this mode: saving the identify time and the walking time, and the walking time accounted as much as more than 70% of the entire order picking time. So the key to reduce the walking time when picking an order is to reduce the pickers' unnecessary walking.
Reduce the order pickers' unnecessary walking can perform in two ways: Firstly, strict control the picker' order picking operation; secondly, design a rational picking route in order to assure the order picker walk the shortest way. Our main concern here is to design the optimal path of picking makes the picker walk the shortest distance to make the order picking efficiency maximum. The purpose of the serial partition Relay picking mode is to reduce picking time, improve the response time of the orders, the key is to design a rational picking route to make the order picker walk the shortest way. We can improve the reaction speed of the order and to reduce the response time by this way, so that it can improve the Supply Chain Execution System efficiency of China Post Logistics' medical warehousing field.

4. Ant Colony Optimization design based on serial partition relay picking model

Symmetric TSP problem is the most basic lining problem, this problem can be seen as the a single traveler who stars from one city, travelling to the other cities, and minimum the walking distance, it is a typical NP-hard problem and difficult to find the accurate solution, especially in solving large scare problems [6-7]. Since the TSP problem was put

forward, many scholars get a deep research in this issue and improved the solving method. For the general method of solution is to use intelligent algorithms, such as ant colony optimization [8]. The paper below shows the ant colony optimization applied to serial partition relay pick mode path optimization research and hope that it can draw a conclusion.

The algorithm above is similar to the traditional TSP problem [9, 10]. And the mathematical model of this problem can be constructed as below.

$$\min \quad z = \sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij} x_{ij}$$

$$s.t. \quad \sum_{j=1}^{n} x_{ij} = 1 \qquad i = 0,1,2\cdots n$$

$$\sum_{i=1}^{n} x_{ij} = 1 \qquad j = 0,1,2\cdots \mathrm{n}$$

$$x_{i_1 i_2} + x_{i_2 i_3} + \cdots + x_{i_k i_1} \le k-1 \qquad k = 2,3,\cdots, \mathrm{n}-1$$

$$x_{ij} = 1 \ or \ 0$$

We set w_{ij} Means the distance between the goods i and goods j, x_{ij} =1 means the cargo move from position i to position j the moment, x_{ij} =0 means the picking truck don't cross the route i and route j.

In the formula listed above

$$\min \quad z = \sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij} x_{ij}$$

Means the shortest distance of the order pickers' walking distance.

$$\sum_{j=1}^{n} x_{ij} = 1 \qquad i = 0,1,2\cdots n$$

$$\sum_{i=1}^{n} x_{ij} = 1 \qquad j = 0,1,2\cdots \mathrm{n}$$

These two formulas mean that the loop can only go through each vertex once and the only once.

$$x_{i_1 i_2} + x_{i_2 i_3} + \cdots + x_{i_k i_1} \le k-1 \qquad k = 2,3,\cdots, \mathrm{n}-1$$

This formula means the model will not include the loop with k vertexes.

When we use the ant colony optimization model to solve this problem, we suppose that there are m ants, and each ant has the following features: the ants select the next visiting city by the probability of the pheromone and the distance between the current city and the next one ($\tau_{ij}(t)$ refers to the probability of line $e(i, j)$ at t time).

We set the ants goes the legal route and unless the ant visited all the cities, there are not allowed to visited the city which they have visited before. In order to prevent this situation to happen, we set a tabe table (we set that $tabu_k$ is the table of ant k and the $tabu_k(s)$ is the sth element). When the ant completed a circle, the ant left the pheromone on every route it walked.

The amount of pheromone on each route is the same at the initial time, and we set $\tau_{ij}(0)=C$ (C for constant). When the ants are moving, the ant choose the next city by the amount of pheromone on the linking route, and $p_{ij}^{k}(t)$ means the probability of ant k moving from city I to city J at time t.

$$p_{ij}^{k} = \frac{\tau_{ij}(t) \bullet \eta_{ij}^{\beta}(t)}{\sum_{s \in allowed_k} \tau_{is}^{\alpha}(t) \bullet \eta_{is}^{\beta}(t)} \qquad if \quad j \in allowed_k$$

$$p_{ij}^{k} = 0 \qquad otherwise$$

$allowed_k = (0,1\cdots \mathrm{n}-1) - tabu_k$ refers to the next city allowed to select for ant k, and we use $tabu_k(k = 1,2,\cdots \mathrm{m})$ to record the cities the ant visited, it can be dynamic adjustment with the evolution process. η_{ij} stands for the inspiration function, and it refers to the arc of visibility, it can be find out by some heuristic algorithms, in general, $\eta_{ij} = 1/d_{ij}$,and d_{ij} means the distance between city i and city j. a refer to the important degree of the path, β refers to the importance of the visibility. After n periods of time, the ants complete a cycle, and the amount of information need to be adjusted according to the following formula:

$$\tau_{ij}(t+n) = (1-\rho) * \tau_{ij}(t) + \Delta\tau_{ij}$$

$$\Delta\tau_{ij} = \sum_{k=1}^{m} \Delta\tau_{ij}^{k}$$

In the formula above, ρ means the volatile coefficient of the pheromone, $\rho \in [0,1]$, refers to the amount of pheromone left by the ant k on route ij, and $\Delta\tau_{ij}$ refers to the increment of pheromone on the route ij in the cycle.

The steps to simulate this mathematic model can be describes as below:

1th step: Initialize all parameters: $\alpha, \beta, \rho, C, Q$, posing the number of ants is m, the number of nodes is n, place the ants to node (that is picking containers that goods need to be sorted) as each ant's initial position;

2nd step: Calculate the distance between each node (Euclidean distance), and calculate the visibility of t

moment, the visibility is the reciprocal of the distance between the nodes;
3rd step: Start the iteration of the algorithm;
4th step: ants move from node i to the next node. The moving probability is decided by probability function above. At the same time update the table tabu. If the table is not full so continue searching until a path search is complete and then return to point of origin;
5th step: Record the shortest path, and release the tabu lists, if the number of the iterations is less than the specified number of iterations, then restart the interation from the 3rd step;
6th step: Find the shortest path as an end result from all optimal paths and results;
7th step: Output the best path.
The steps of this simulation described above and the ant colony algorithm's iterative process is shown in Fig 3 below.

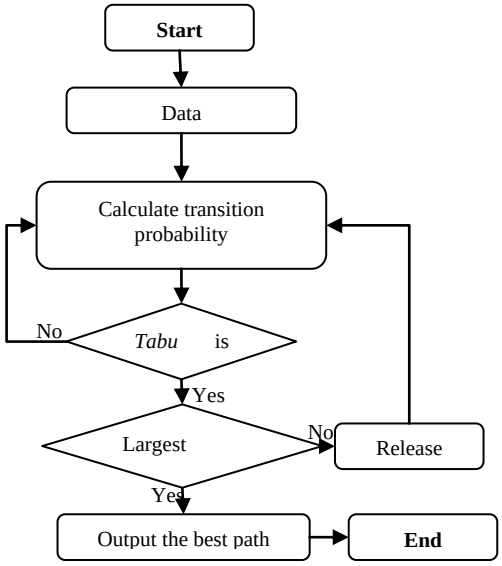

Fig. 3 Ant colony Optimization's iterative process

5. Numerical example and effectiveness

We use MATLAB R2010a to program this algorithm to completed the following examples. The examples assume that a digital picking machine positioning the place by the lights on the shelves to pick up the goods, we assume that the tally at coordinates (0, 0) and the other various coordinates are（36，15）、（1，22）、（37，13）、（34，35）、（32，16）、（23，22）、（41，4）、（31，9）、（36，8）、（37，27）、（6，36）、（27，49）、（23，16）、（33，9）、（15，16）、（18，21）、（31，23）、（37，22）、（36，28）、（29，28）、（43，21）、（39，18）、（37，23）、（34，23）、（34，31）、（23，24）、（30，20）、（25，27）、（28，26）、（20，25）,and these 30 kinds of medicine are in 6 libraries. In the analysis of this example, we select the algorithm to interaction 7 times and observing the final results, these results show in Table 1 below:

Table.1 Iteration results

Num. of Calculations	1	2	3	4	5	6	7	Mean
Num. of Iterations	30	50	100	150	200	250	300	
Routings	282	278	276	282	282	280	284	280.6

The average optimal solution in table 1 is 280.60, and the optimal solution is 276. The results in table 1 shows: it is almost the same when the integration times is more than 100, and the best interaction time is 100 times. With the increasing of iterations, the computation time required is increasing, the compute efficiency is decreasing, and too short interactions lead the result not too accurate. Therefore, we interact 100 times to generate as the optimal solution. Fig 5 and Fig6 shows the specific picking route and the average total route when interact 100 times.

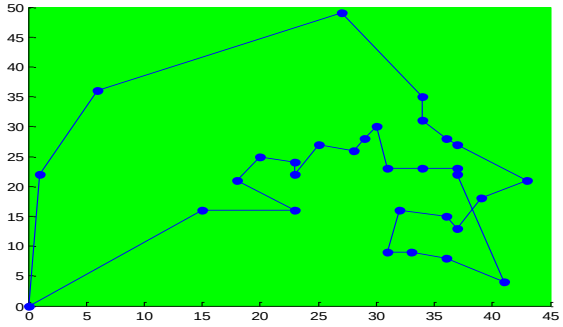

Fig.4 The origin order picking route under parallel partition picking mode

Before the optimization of the system, the order picking mode is parallel partition relay picking model, in the mode, 6 order pickers responsible for an order, each of the take responsible for good picking in their own library district. Such picking strategy enormous waste of the human resources, and when a picker finish his own work, he sent the order to the next order in the neighbor picker, it is a big waste for China Post Logistics' warehouse. In a cost analysis, we find that in the original picking system, every order need 1.21 order pickers and the average picking distance is as much as 310.42 units (show in the Fig4). In

the new order picking mode, each order only need one order picker and the walking distance is only on the average of 280.60. Not only to this, this mode don't need to splitting the orders.

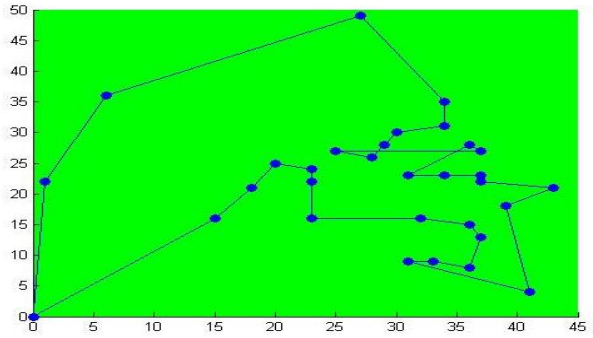

Fig.5 The specific optimal order picking route under Serial partition relay picking model

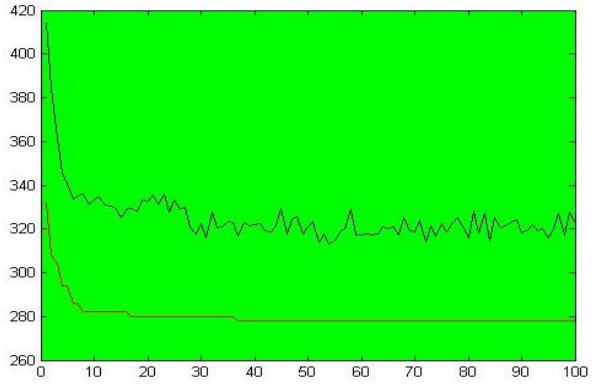

Fig.6 The average total optimal order picking route under Serial partition relay picking model

Consider from the human resources cost consumption, the cost of order picking in the warehouse reduce 17.36%. Consider from the distance of the order picking path, more than 9.80% decrease than that as before. The results show the order picking mode and the route planning is effective.

6. Conclusions

This paper design a new order picking mode in China Post Logistics' medical logistics business area by analyzing the existing problem of this field, and then design the order picking route by using the Ant Colony Optimization. At last, it made numerical examples through MATLAB simulations. The example simulation result shows that this optimizing is effective and the order picking cost decrease 17.36% and the route decrease 9.80% than that as before. This research not only to Chain Post Logistics but also to other logistics company which runs the medical business has certain reference.

Acknowledgments

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