CASE STUDY: VEHICLE ROUTING PROBLEM WITH TIME WINDOWS FOR A SHOP IN FISHERIES WHOLESALE MARKET

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Abstract - This paper proposes a methodology for Vehicle Routing Problem with time windows (VRPTW). VRPTW deals with routing of vehicles for distribution management considering time constraints. This problem was found by a shop (a company, so to speak) which is located in Noryangjin Fisheries Wholesale Market, Seoul, Republic of Korea. VRPTW is solved using heuristic algorithms such as Route-building, the neighborhoods, or metaheuristic algorithms. This study uses an algorithm which is combined modified Tabu search and Simulated annealing. We analyze that the effects of applying new routes after the use of suggested algorithm and the shop (company) is able to save distribution cost and resources dramatically in comparison to the current business system.

Indexterms - Logistics,Transportation business, VRPTW, Time window, Metaheuristic, Tabu search, Simulated annealing.

I. INTRODUCTION

Some large fisheries wholesale markets, such as Noryangjin Fisheries Wholesale Market, share part of the fish industry in Korea. Many products delivered from these wholesale markets to smaller markets. This is because of the high transportation cost in the fish industry in Korea. Therefore, optimizing the transportation process is a very important part to the wholesaler's benefit. One of the traditional wholesale markets in Korea,Noryangjin Fisheries Wholesale Market, uses an inefficient transportation system. The Korean government tried to change these setbacks, but we interview to people who work in the Noryangjin Market, the effort to improve system by the Korean government wasn't effective.

This paper focuses on a specific company located in theNoryangjin Fisheries Market. The company distributes fishes from Noryangjin Fisheries Wholesale Market to other markets located in Gyeonggi-do (province) and Chungcheong-do. The paper analysis this company's current transportation system and suggest a better system for the company.

II. CURRENT SYSTEM

The company has 5 steps before reaching completed delivery. First of all, they buy the product through the auction market which started around 0 A.M. After that, products are stored in a warehouse. They have a meeting about the vehicle routing. This process takes approximately 1 hour and 30 minutes to finish. Fourthly, products are loaded from the storage to trucks. It should be finished by 5 A.M. and then they start the delivery process.

During this process, the vehicle routing process has some issues about time and quality. It makes the company spend more money, time and resources. For an effective operation and preventingloss of money, companies try to solve this situation by using Vehicle Routing Problem (VRP).

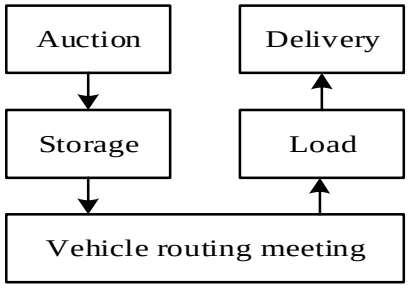


Figure 1: Steps of process

III. LITERATURE REVIEW

[1]explained the Vehicle Routing Problem with Time Window (VRPTW) as very time consuming to solve. This problem is known as NP-hard. Therefore, several methodologies are used to solve VRPTW in a reasonable time. VRPTW is solved using methodologies which are metaheuristic and heuristic algorithms. [2]introduced the algorithms which are researched over the past 20 years. In the paper, three different types of heuristic algorithms, whicsh are Route-building heuristics, Route-improving heuristics and The neighbourhoods for the VRPTW, are introduced. Metaheuristics algorithms named Simulated annealing, Tabu search and The genetic algorithm are shown in the paper. Route-building heuristics are explained in [3, 4,5]. The neighourhoods for the VRPTW are shown in [6, 7, 8]. Metaheuristic algorithms' details are introduced in [9, 10, 11].

IV. METHODOLOGY

The problem consists of two parts which are clustering demands and the routing problem. This paper use the concept of Tabu search and Simulated annealing which is an old metaheuristic methodology.

Our research uses modified Tabu search for the clustering demands part and Simulated annealing for the routing problem part.**1. Tabu search**
VRPTW has a very limited feasible solution space.Therefore, in this paper, modified Tabu search is used to solve it.

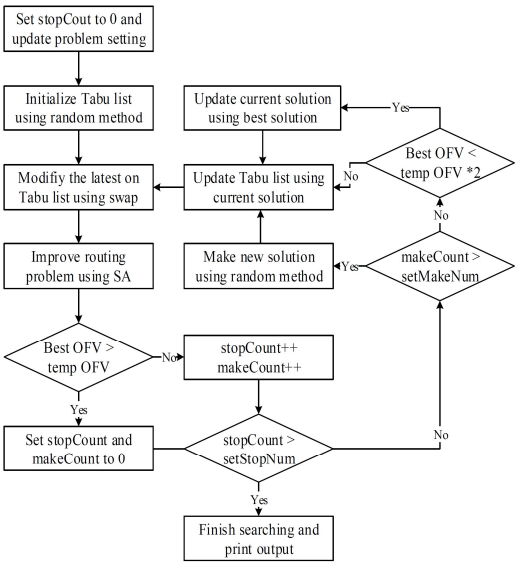


Figure 2: Modified Tabu search algorithm

Figure 2 shows the outline of the modified Tabu search algorithm. In order to improve the quality of solution, this algorithm uses some methods. One of the methods is using several starting points of the algorithm. The other is adjusting the current solution to prevent the quality of the solution from getting worse.

2. Simulated annealing

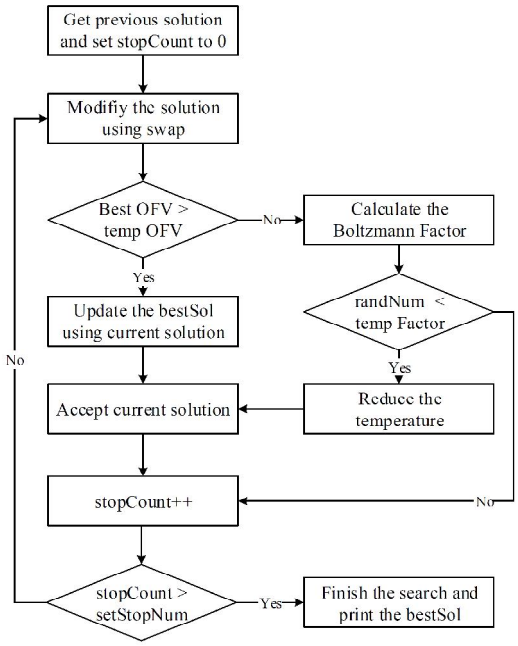


Figure 3: Simulated annealing algorithm

Our paper uses Simulated annealing to narrowing the solution space. The problem should be solving in the business operational time. Therefore, in this paper, Simulated annealing parameter is set as borrowing a concept of heuristic algorithm to search until restricted times. Brief Simulated annealing logic, which is used in this paper, is explained in Figure 3.

V. EXPERIMENTAL MODEL

1. Current model

The company analyzedby our research uses 7 trucks for each day. Currently, the two types of trucks are operated for the delivery. One of the truck types is 2.5-ton truck and the other type is a 1-ton truck. The company spent approximately 12 million KRW per month on truck running charge and about 35 million KRW per month on salary for 10 employees. The company has 23 fixed contracts on delivery products. The details are listed in Table 1 and 2

Contents	Detail
Employees	10
Contracts to delivery	23
Salary for Employees	35 million per month
Truck running charge	120 million per month

Table 1

Type of truck	Amount of truck
1-ton truck	6
2.5-ton truck	1

Table 2

Truck type	Truck No.	Distance(Km)	Weight(Kg)
1-ton	1	255	880
	2	349	642
	3	282	967
	4	357	332
	5	207	994
	6	369	519
2.5-ton	7	181	1606
Total		2000	5940

Table 3

Our research analyzed one specific business day of the company which is Nov. 4th, 2017. On that day, the company used 7 trucks to deliver the products. The total distance for delivery on that day was approximately 2000 Km and the meeting for the

vehicle routing was tookaround 1 hour and 30 minutes. The details of each truck's distance are listed in Table 3.

VI. EXPERIMENTAL RESULT

The methodology was implemented with the following specifications: Java jdk1.8, Intel-Core-i7 CPU(2.60GHz) processor, 16 GB of memory and Window 10. The paper planned two experiments to check the quality of solution and to solve the company's problem. For checking the quality of solution, the experiment was conducted using Euclidean distance with no other constraints. The other experiment considered the time window and the real distance of road. Firstly, for the no constraint problem's one of the results is shown in Figure 4. This problem has four assumptions: using five different unlimited capacity trucks, using Euclidean distance, considering no time limit and considering no unloading time on the demand location. The result is the case which uses five unlimited capacity trucks. Each truck has a separated section for delivery. For solving the problem, the total runtime of the algorithm was about 85.48 seconds.

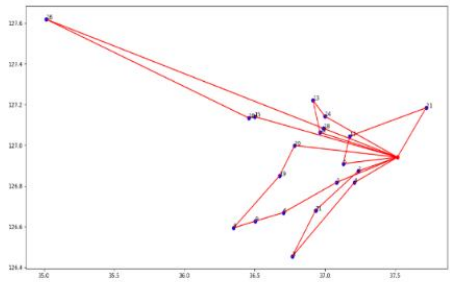


Figure 4: Result of experiment which is no constraint and Euclidean distance

In the second case, theactual problem of the company considered five assumptions: using four different 1-ton trucks and one 2.5-ton truck, using real distance, considering the time limit on a few demands, considering unloading time as 20 minutes on demand locations and using a constant velocity of the truck which is 75Km per hour. The result of this paper is listed in Table 4. Figure 5 is two routing which are samples of the results shown on the map.Total runtime of the algorithm when solving this problem was 282.73 seconds. The result shows that the total distance is able to be reduced by 29.3 percent.

Truck type	Truck No.	Distance(Km)	Weight(Kg)
1-ton	1	244	899
	2	336	986
	3	229	630
	4	216	967
2.5-ton	5	389	2458
Total		1414	5940

Table 4

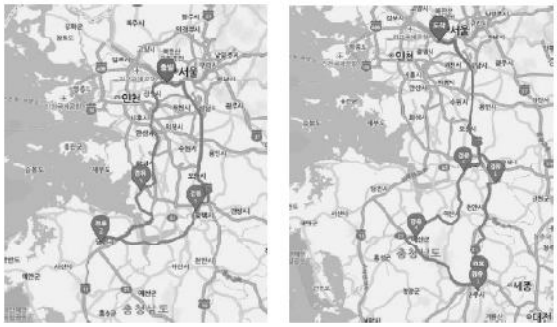


Figure 5: Samples of truck routing
Source: Naver Map(2017)

CONCLUSION

In this paper, a methodology, which is a combination of Tabu search and Simulated annealing, to solve VRPTW is introduced. Moreover, our research solved the actual problem considering the operational situation. The main advantage of this paper is finding a better solution than the real actions conducted by in the company. This advantage can make a chance to reduce the surplus of money and resources. However, to actually reduce the surplus, the company needs to make a new business model which is adapted through our research. Our research has several assumptions which could be removed. For example, this paper considered unloading time and velocity of the truck as constants. In the future, this parameter can be considered as dynamic.

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