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Analysis and optimization of the pharmaceutical distribution chain of NIGAPHARM company: A case study in Algeria

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Abstract— Pharmaceutical distribution chain represents one of the most difficult distribution chains to manage. It is made up of several intermediate links that must interact in order to satisfy customer demands. The system under study represents a real world case in Algeria; we noticed that the circuits used by delivery's vehicles are not optimal after analyzing the distribution chain of the company. This paper deals with NIGAPHARM's distribution network and propose to minimize the total distance driven by the vehicles for short and long distances by selecting the optimal routes planning respecting realistic constraints of this VRP problem.

Key words: Pharmaceutical products, distribution chain, optimization, VRP, minimization of distance, client's demand satisfaction, optimal circuit.

I. Introduction:

Distribution is an element that allows goods (products or services) to be available to the final consumer. It consists in managing all the means so that these goods are available at the right place, at the right time and with the desired quantities.

Generally, pharmaceutical distribution chain composed of producers, wholesalers and pharmacies. However, in this work we address the delivery section from the wholesaler (NIGAPHARM) to pharmacies.

This work aims to minimize the total travelled distance by choosing the shortest circuits from the depot to clients.

The paper remainder structure as follows. The next section details the problem statement with the case study description and optimization model. Section III shows the obtained results. Finally, the paper ends with a conclusion and some perspectives presented in the last section V.

II. Problem statement:

The Vehicle Routing Problem (VRP) is an old problem in operation research it was stated in late 50's of the last century when Danzig and Ramser established the mathematical programming formulation and algorithmic approach to solve the problem of gasoline delivery to service stations^[1].

This paper deals with a VRP problem for a real case study in Algeria. The system under study consists to choose the shortest paths to deliver pharmaceutical products from the depot (NIGAPHARM Company) to several pharmacies in different cities and return to the warehouse.

Problem description:

Our problem is divided into two parts, one for deliveries to the wilaya of Tlemcen - called short distance delivery - and the other for deliveries outside the wilaya of Tlemcen called - long distance delivery - ensuring that all customers are served. The objective is to find a delivery schedule that minimizes the distances covered and therefore the duration of the vehicle tour respecting several constraints such as:

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- ✓ The same driver makes the same trip with the same customers.
- ✓ A long distance driver does not work two consecutive days.
- ✓ On the same day, you don't have to pass through all the cities (for long distance).
- ✓ In the same day, the number of vehicles cannot be exceeded.
- ✓ The same vehicle can make to the same circuit more than once a day.
- ✓ It is assumed that the time of use of a vehicle is 4 h/rotation for short distances and 10h for long distances.
- ✓ It is assumed that the company makes 2 rotations/day for short distances and 1 rotation for long distaces.

Objective fuction:

The objective function **(1)** of our problem is to find a delivery schedule that minimizes the distances covered and therefore the duration of the vehicle tour respecting several constraints.

Optimization model:

Nomenclature

Parameters:

- N number of cities to visit, the cities are numbered from 2 to n and the warehouse has the number 1
- T time to use a vehicle.
- Q time of travel within a city.
- U accumulated travel time.
- Time (i,j) Time between city i and j
- Knowing that: $T(i,j)=Q(j)+Time(i,j)$

Variable:

1 if a vehicle makes the path (i,j)

$X_{ij} =$

0 otherwise

Objective function:

$$\text{Min } Z = \sum_{i=1}^N \sum_{j=2}^N T_{i,j} * X_{i,j} \dots\dots\dots(1)$$

Constraints:

$$X_{(k,k)} = 0; \forall k > 1 \dots\dots(2)$$

$$\sum_i X_{(i,k)} = 1; \text{ tq : } i \neq k, \text{ et } (i = 1 \text{ ou } Q(i) + Q(k) \leq T) \quad \forall k > 1 \quad (3)$$

$$\sum_j X_{(k,j)} = 1; \text{ tq : } j \neq k, \text{ et } (j = 1 \text{ ou } Q(k) + Q(j) \leq T) \quad \forall k > 1 \quad (4)$$

$$\forall k > 1 \quad Q(k) \leq U(k) \leq T \quad \dots\dots(5-1)$$

$$U(k) \geq U(i) + Q(k) - T + T * (X_{(k,i)} + X_{(i,k)}) - (Q(k) + Q(i)) * X_{(k,i)};$$

$$\forall (i \neq k), \text{ et } (i \neq 1);$$

...(5-2)

$$U(k) \leq T - (T - Q(k)) * X_{(1,k)}; \dots\dots(5-3)$$

$$U(k) \geq Q(k) + \sum_{i>1} Q(i) * X_{(i,k)}; \dots\dots(5-4) \quad \}$$

$$X = \{0, 1\} \quad \forall i, j \quad \dots\dots(6)$$

(2): This constraint ensures that travel to the same city is impossible.

(3): This constraint ensures that the vehicle must start from the warehouse to one city or from one city to another.

(4): This constraint ensures that the vehicle must return to the warehouse or leave the served city.

(5): This constraint is composed of several equations:

(5-1): specifies the interval of the parameter U that represents the accumulated travel time (between the travel time within the city and the maximum vehicle used time).

(5-2): formula that calculates the accumulated travel time if k is the next city to be visited after i.

(5-3): formula that calculates the accumulated travel time if k is the first city to be visited after the warehouse.

(5-4): formula that calculates the accumulated travel time if k is not the first city to visit after the warehouse.

(6): This equation shows the binary nature of the decision variable X.

III. Results and discussion:

In order to solve this problem, we choose LINGO software as a solver. Therefore, these are the obtained results by optimization:

For short distances:

The routes of each vehicle: with 2 rotations/day

Vehicle 1	Warehouse- City 2 - Warehouse
Vehicle 2	Warehouse-City7-City4-City3-Warehouse
Vehicle 3	Warehouse-City8-City12-City13-City11-City 10-City 9-City 5-City 6-Warehouse
Vehicle 4	Warehouse-City 18- City 17-City 15- City 16- City 14- City 19- City 20- City 21-Warehouse

Table I: New schedule for short distance deliveries.

For long distances:

We obtained 6 circuits with different rotations/week:

Circuit1	Warehouse - City 9 - Warehouse	3 rotations/week
Circuit2	Warehouse-City7-City8- Warehouse	2 rotations/week
Circuit3	Warehouse-City4- Warehouse	2 rotations/week
Circuit4	Warehouse-City2-City1 -Warehouse	4 rotations/week
Circuit5	Warehouse-City 6-Warehouse	1 rotations/week
Circuit6	Warehouse-City5-City3-Warehouse	2 rotations/week

Table II: New circuits for long distance deliveries.

Discussion and comparison:

For short distances:

The obtained results for short distances allow the improvement of the distribution of the company's products by reducing the duration of the tour from **1371 minutes** to **1278 minutes**, with a gain of **93 minutes**, which represents a **6%** reduction compared to the initial duration.

For long distances:

We have proposed a new schedule for long distance deliveries, which has allowed us :

- To have one more rotation for the city2.
- To minimize the number of vehicles per day to 3 vehicles instead of 4 vehicles initially used.
- To minimize the total time of the routes during all the week of **521 minutes ≈ 8h41min** where the initial total time of the routes is **8453 minutes ≈ 140h53 min** while the new total time of the routes obtained is **7932 minutes ≈ 132h12min**, which represents an improvement of **6%** compared to the initial duration.

IV. Conclusion:

Our work consisted in studying the distribution system of the company NIGAPHARM in Algeria and proposing improvements of the distribution chain of this company by using LINGO solver. Therefore, a 6% improvement in total travelled time is obtained with new schedules proposed. The work presented in this paper could be improved by taking into consideration the constraints of time slots or time windows that customers prefer or require for their deliver, also by introducing some constraints related to the product itself and the respect of the temperature constraints for example and the test of the resilience of the supply chain in regarding vehicles problems or demand variation.

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