LOCAL DELIVERIES TIME OPTIMIZATION FOR CITIES WITH UNSTABLE TRAFFIC

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KEY WORDS
Delivery, Optimization, Route, Unloading.

ABSTRACT

The paper deals with delivery and vehicle unloading time importance for local distribution problems within practicable conditions. It is necessary to optimize both vehicle's driving time and unloading time to organize local circular route in optimal way.
The paper's author recommends registering vehicle unloading time for the each object within the particular route. It is also recommended to divide all roads into small sections. After that it is easy to define driving time for each section in particular hours.
The author also advises the investigation of distribution processes' service quality as well as distribution costs to improve circular route planning for local deliveries.

INTRODUCTION

Accuracy factor is really important for production delivery nowadays. Customers want to receive cargo on time and without delays. Carriers wish to use their vehicles in optimal way. Designing of the optimal circular route especially for cities with intensive traffic is a complicated problem. Traffic congestions in big cities are not constant; they may change by hour of day or day of week. So, often it is impossible to use common mathematic methods for route planning, because these methods will not provide the optimal result in practical conditions. If a specialist analyses all possible variants, he will spend a lot of time for planning process. Distribution process planning for cities is a sophisticated process due to loading of city's roads and unstable vehicle unloading time for particular objects.

CIRCULAR ROUTE PLANNING PROBLEMS

Routing is the cornerstone of modern logistics and transport environment. It is necessary to plan routes in optimal way in order to serve customers better than competitors. Actually, if the company has the optimal route, it also provides higher level of customer service for delivery of goods. On the other hand, optimal planning allows decreasing company's costs, connected with delivery of cargo. Sometimes one vehicle should serve 10 or more customers within the particular route (Figure 1). Normally circular route (connecting large number of customers) planning is a complex process for cities and other built-up areas, because there are many different ways of completing it. Often operators make a typical mistake during the routing process; they try to minimize only vehicle's way, serving customers within the particular route.

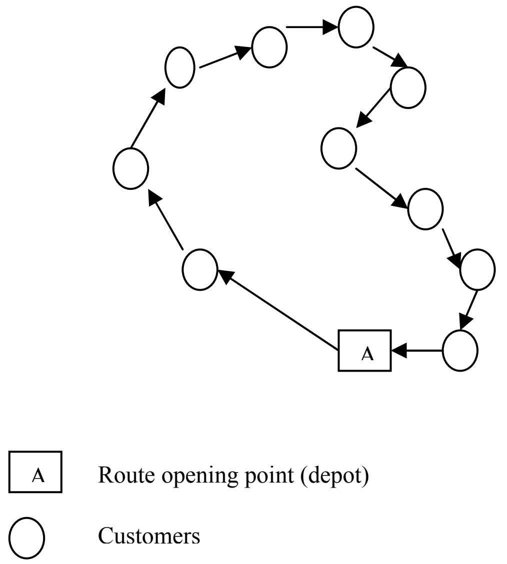


Figure 1: One Vehicle Serves Large Number of Customers (Circular Route).

The total time of delivery within one route consists of the 2 main elements: vehicle moving time and vehicle unloading time (figure 2, formula 1).

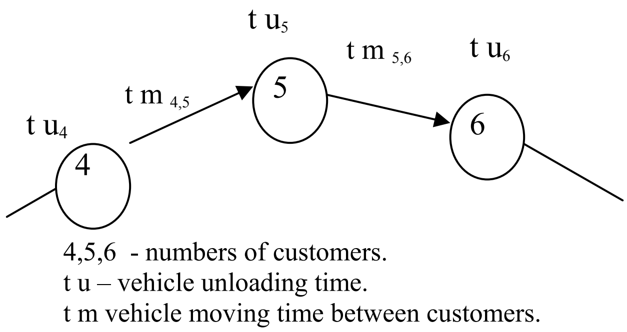


Figure 2: Circular Route's Fragment.

$$T_d = \sum_{i,j=1}^{n} tm_{ij} + \sum_{i=1}^{m} tu_i \qquad (1)$$

T d – total delivery time
tm_{ij} - Vehicle moving time between the route's points *i* and *j*.
t u*i* –Vehicle's unloading time for customer *i*.

Proceedings 22nd European Conference on Modelling and Simulation ©ECMS Loucas S. Louca, Yiorgos Chrysanthou, Zuzana Oplatková, Khalid Al-Begain (Editors)
ISBN: 978-0-9553018-5-8 / ISBN: 978-0-9553018-6-5 (CD)

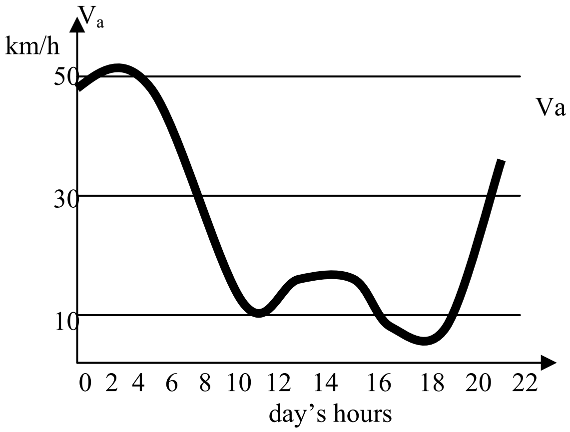


Figure 3: The Average Vehicle’s Speed (Va) Variables For Particular Crossroad in Riga by Hour (on Monday).

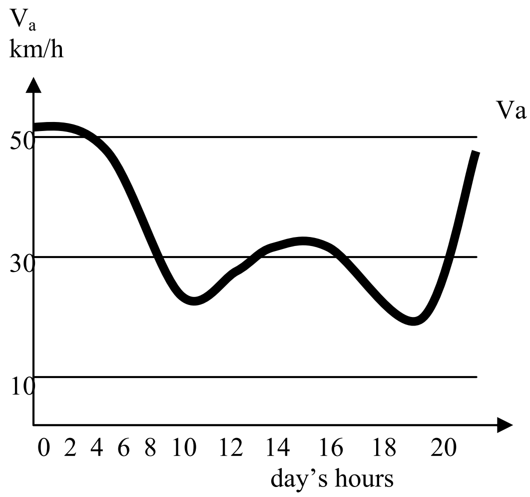


Figure 4: The Average Vehicle’s Speed (Va) Variables For Particular Crossroad in by Hour (on Tuesday).

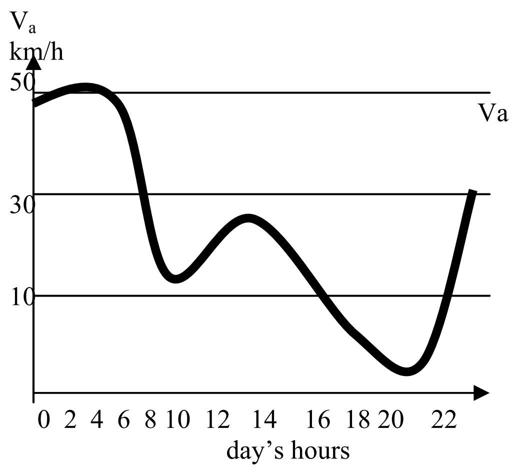


Figure 5: The Average Vehicle’s Speed (Va) Variables For Particular Crossroad in Riga by Hour (on Friday).

Basically, while planning local deliveries it is necessary to solve two problems. On the one hand, it is necessary to organize accurate deliveries. On the other hand, operator should reduce the time, the vehicle spends, serving the particular route.

Today, designing an accurate delivery time is quite involved, because traffic congestions are unstable, they may change depending on days of the week or particular hours of the day [3]. The average vehicle’s speed also changes – (figure 3-5)

The average vehicle’s speed in the particular stage of Riga’s street is unstable; it changes not only at the particular hours, but also on the particular days of week. The highest speed is at night (between 11 p.m. and 4 a.m.), but it not high at least at morning hours. The level of average speed is the lowest at 6.a m.-10 a m. and 17 p.m.-19 p.m. in several streets of Riga on Monday. This index changes on other days of the week (figure 4-5).

Scientific methods and computer programs may be used to solve particular time-planning problems, connected with routing, though every method or program has different cons, for delivery planning within cities. For example, mathematical methods need fixed information about time, speed and other factors, but in our case these factors vary, making it impossible to achieve the optimal result using only mathematical methods. In this case it is possible to achieve the optimal result, only by using special methods, programs and specialists’ experience combined.

VEHICLES MOVING TIME PLANNING PROBLEM’S SOLUTION FOR CITIES WITH HEAVY TRAFFIC

Generally, it is possible to use only micro-elements method to improve route planning in cities with heavy traffic. To explain it we may investigate the following example.

The time of delivery consists of two basic positions: time of driving and time of loading/unloading. Specialist’s task is to consider these elements for the particular route. It is possible to plan driving time precisely, if we use the following approach for solving routing problem.

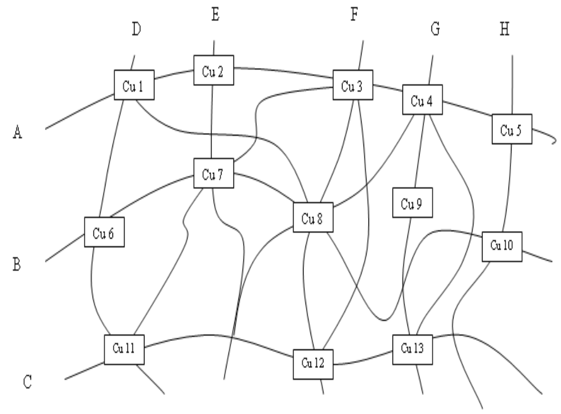
1.step. To create “roads’ passport”. It is necessary to divide the particular territory’s roads into different elements. Normally, may use different division basics– between two crossroads, between two customers, between a crossroad and a customer, between two traffic lights etc. (figure 6)

2.step. Notice, what is the average speed of driving at the particular hours for the each element. (figure 6)

3.step. Creating a database of average speed for the each element into particular hours of the day and day of the week. (1 table)

According to the information of Table 1, for instance, the average speed for road’s elements A2, B3, B2,C2 and C1 at 7-8 a m. is 5 km/h, but at 10-11 a.m. it is 5-10 km/h.

The average speed for road’s elements A1 and B1 at 7-8 a.m. is 5-10 km/h, but at 10-11 a.m. it is 15-20 km/h.



A,B,C- main roads' names;
D,E,F,G,H – other roads names.
Cu 1 – Cu 13 –customers names

Figure 6. Roads, Divided Into Particular Elements.

Table 1: Example of Vehicle Average Speed in the Particular Roads Elements Depending on Hours of a Day.

a)

Hours of a day / The average speed	7-8 a m	8-9 a m	9-10 a m	10-11 a m	11-12 a m
5km/h	Cu6-Cu1, Cu1–Cu2, Cu2-Cu7	Cu8-Cu7, Cu1–Cu2, Cu2-Cu7	Cu8-Cu7, Cu1–Cu2, Cu2-Cu7	Cu8-Cu7,	Cu1–Cu2,
5-10	Cu3-Cu8,	Cu1–Cu2,		Cu8-Cu7, Cu3-Cu8	Cu1–Cu2, C2-C7
10-15	Cu2-Cu3 Cu6-Cu7	Cu2-Cu3 ,	Cu6-Cu7	Cu2-Cu3 Cu6-Cu7	Cu2-Cu3 Cu6-Cu7
15-20				Cu1–Cu2, Cu2-Cu7	
20-25					
25-30					
30+	Cu5-Cu10, Cu9–Cu13, Cu4-Cu5 Cu4-Cu9	Cu4-Cu5 Cu4-Cu9	Cu4-Cu5 Cu4-Cu9	Cu4-Cu5 Cu4-Cu9	Cu5-Cu10 Cu9–Cu13, Cu4-Cu5 Cu4-Cu9

b)

Hours of a day / The average speed	12-14	14-15	15-16	16-17
5km/h				
5-10	Cu8-Cu7, C11-C7	Cu1–Cu2, C11-C7	Cu2-Cu7	
10-15	Cu2-Cu3	Cu6-Cu7	Cu2-Cu3 Cu6-Cu7	Cu6-Cu7
15-20	Cu2-Cu7	Cu8-Cu7,	Cu1–Cu2,	Cu2-Cu7
20-25	Cu5-Cu10			
25-30				
30+	Cu9–Cu13, Cu4-Cu5 Cu4-Cu9	Cu4-Cu5 Cu4-Cu9	Cu4-Cu5 Cu4-Cu9	Cu5-Cu10, Cu9–Cu13, Cu4-Cu5 Cu4-Cu9

Cu 1 – Cu 13 – Customers names (from figure 6)

Creating such a database is an involved process; specialists should spend a lot of time to complete it. Using this database helps operator to plan vehicle's moving time in optimal way. Table 1a) is the first part of database, involved information about the period of time between 7 a.m. and 12 a.m. Table 1b) includes information about average speed in the particular roads elements for the period of time between 12 and 17. If the distance of the particular road's element is known as well as the vehicle's speed in the particular hour, we may plan the time we spend to drive through this element. Certainly, it makes route planning process easier and helps to create the optimal delivery precisely. In this way it is possible to decrease vehicle moving time uncertainty, but it is not enough for delivery optimization in general. It is also necessary to plan vehicle's unloading time for each customer.

VEHICLES UNLOADING PROCESSES TIME CONTROL OPTIMIZATION

According to formula 1, in order to achieve the best delivery time planning, it is necessary to improve planning of vehicle unloading time for each customer. If there are 50 customers within the particular route and the operator makes a five-minute mistake while planning of unloading time for each customer, the total mistake exceeds 4 hours (approx. half of the total working hours). There are 2 possible alternatives in this case:

-vehicle's driver serves all customer 4 hours earlier and returns to the depot. (Vehicle has 4 additional hours of idle time in this case);

-vehicle's driver does not have enough time to serve customers during his working hours.

Both situations are unsuitable for the operator; and it is necessary to improve vehicle's unloading time control to satisfy company's customers.

It is essential to create vehicle's discharging time system for all company's customers.

First of all, one may divide unloading process to separated elements:

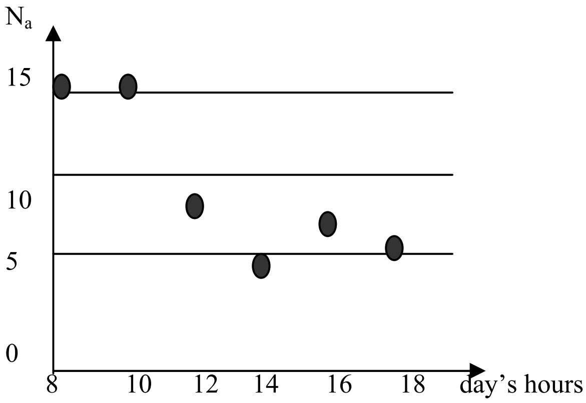
1. vehicle wait time (in a queue) while other vehicles will be discharged by the particular customer. (T w)
2. vehicle's maneuvering time by the particular customer.(T m)
3. time needed for driver to park a vehicle. (T p)
4. time needed for driver to get off from the cabin. (T off)
5. time needed for driver to go around vehicle. (T go)
6. time needed for driver to open vehicle's body. (T op)
7. time needed for driver to take a box with goods from the vehicle's body. (T t)
8. time needed for driver to carry the 1 box till a place, where customer receive it. (T c)
9. time needed for customer to check the cargo. (T ch)
10. time to sign documents . (T s)
11. time needed for driver to return into the vehicle.(T r)
12. vehicle's maneuvering time to drive out from customer's territory. (T ma)

Using formula 1, we may specify vehicle's unloading time.

$$Td = \sum_{i,j=1}^{n} tm_{ij} + \sum_{i=1}^{m} tu_{i} \qquad (1)$$

tu_i = T w+ T m+ T p+ T off+ T go+ T op+ T t+ T c+ +Tch+ T s+ T r+ T ma. (2)

It is possible to calculate precisely all these elements, excluding vehicle's wait time (in a queue) while other vehicles will be unloaded by the particular customer, because usually it is too difficult to forecast this index. To optimize delivery time planning it is essential to arrange company's customers.



N_a - the average amount of forwarders, serving the customer simultaneously

Figure 7: The Average Amount of Forwarders Served the Customer Simultaneously at the Particular Day's Hours.

Usually the average number of forwarders, serving the particular customer simultaneously, varies depending on particular hours of a day. Perishable products are usually delivered in the morning. Some warehouses' working time is in progress day and night, but others work only till 5 or 6 p.m. Generally, caterers' concentration is different for each customer depending on particular time of a day.

First of all, it is necessary to investigate the average level of suppliers' concentration near the particular client.

Table 2: Wait (in a Queue) Time Before the Unloading Process Near Company's Customers on the Particular Hours of a Day.

Hours of day / wait (in a queue) time	8-9	9-10	10-11	11-12	12-14	14-15	15-16	16-17
5 minutes	Cu1, Cu2, Cu3.	Cu1, Cu2, Cu3	Cu8, Cu7,	Cu4,Cu5,	Cu1, Cu2, Cu3	Cu1, Cu2, Cu3	Cu1, Cu2, Cu3	Cu7,Cu11, Cu12
5-10 min.	Cu5, Cu8,		Cu1, Cu2, Cu3	Cu6, Cu8	Cu7, Cu11, Cu12	Cu6, Cu8	Cu4, Cu5	
10-15 min.	Cu4	Cu6-Cu7	Cu6, Cu5, Cu12	Cu2, Cu9	Cu9	Cu7	Cu7	Cu4, Cu5
15-20min.			Cu11		Cu8	Cu10 Cu4	Cu11	Cu2, Cu9
More than 20 min					Cu4		Cu13	

Cu 1 – Cu 13 – Customers names (from figure 6)

After this information is collected, it is essential to process it, creating a special system. It is possible to investigate wait (in a queue) time by the each customer (figure 6) at the particular day's hours.

After creating this separated database (2 Table), operator may minimize whole unloading process planning time as well as make the total delivery planning process more precise. Operators or other persons should control vehicle unloading time near the each company's customer on the particular hours of a day. It is not a relational database and it is possible to update it manually changing information about the particular customer.

It is necessary to improve delivery service quality as well as to reduce delivery costs in general.

CONCLUSIONS

It is essential to use micro-elements method, while planning circular routes for cities with intensive traffic. Creation of roads elements average speed's database makes route planning process easier.

Vehicle's unloading time also influences the total time of delivery. Usually it is difficult to register this element of the delivery time because vehicle's wait(in a queue) time may vary for each customer depending on the particular hours of a day. It is essential to divide the total unloading time into separated micro-elements, as well as to create wait time database in order to optimize unloading time control process for local deliveries.

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