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Circular routes planning improvement for cities with intensive traffic

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Abstract: The paper deals with circular route planning problem importance for cities with intensive traffic. It is significant to optimize both vehicle's driving time and unloading time to organize local circular route in optimal way. 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 recommends also of paper advices to investigate customer's demand as well as distribution processes service quality and distribution costs to improve circular route planning for cities with intensive traffic。

Keywords: Circular Route, Optimization, Intensive Traffic, Planning

1. Introduction

Circular route planning is very important problem today especially for cities with hard traffic. Usually companies serve circular routes using auto-transport. 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 in the particular hours or week's days. 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 spends a lot of time for planning process. It is necessary to plan both driving and vehicles' discharging time by optimal way.

2. Routing in Cities with Unstable Traffic

Circular routing is a very important problem 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.

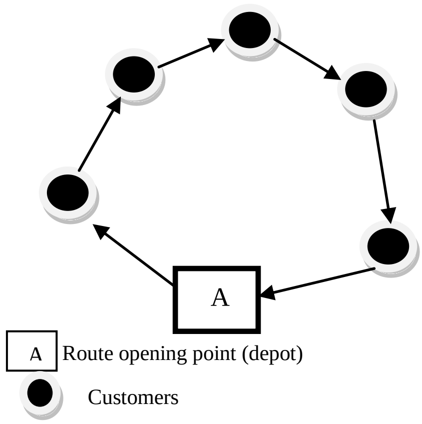


Figure 1: One Vehicle Serves Large Number of Customers (Circular Route).

Sometimes one vehicle should serve 20 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 how to complete 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.

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

$$Td = \sum_{i,j=1}^{n} tmij + \sum_{i=1}^{m} tui \qquad (1)$$

T d -total delivery time

mij - Vehicle moving time between the route's points i and j.

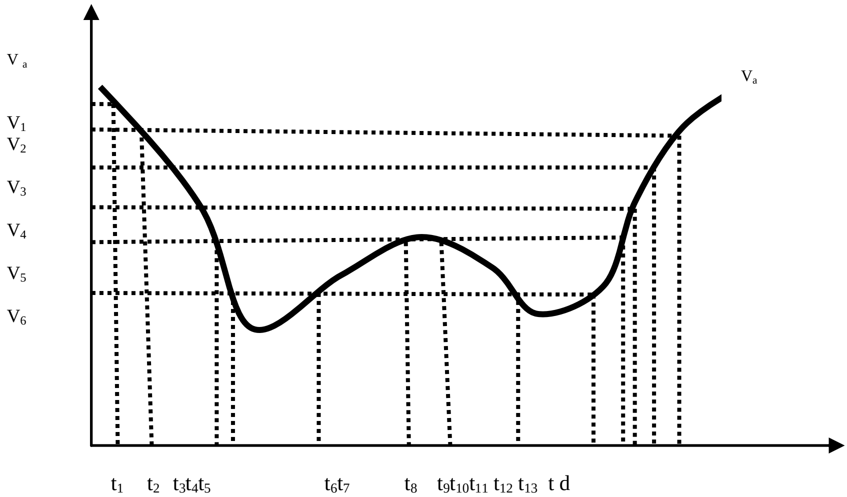


Figure 2.The Average Vehicles' Speed of Particular Route in Riga City in Particular Time Moments.

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, that vehicle spends, serving the particular route.

Today, designing an accurate delivery time is quite involved, because traffic congestions are not stable, they may be change depending on days of the week or particular hours of the day (Patlins, 2006).

It is expediently to divide route's crossroad into 2 groups:

1. Easy for route planning crossroads (auto-traffic does not changes or changes minimally);

2. Difficult for route planning crossroad (due to unstable and intensive traffic in particular day's hours).

The similar principle may use not only for crossroads, but also for other elements of road (between two crossroads, traffic lights etc.)

It is not painful to plan routes for the first group of crossroads, but it is necessary to use special methods to optimize the second group's routing.

It is expediently to divide crossroads from the second group into different classes depending on the average vehicle speed in particular days of week and hours of a day. The average vehicle's speed changes by both days and hours (figure 3-4).

It is possible to group not only crossroads, but also different roads elements between crossroads.

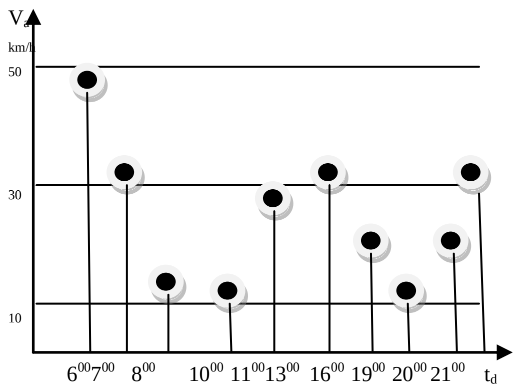


Figure 3: The Average Vehicle's Speed (Va) Variables For Particular Crossroad in Riga in Particular Day's Hours (on Monday and Friday).

According to statistics the average number of vehicles in Riga city is the maximal on Mondays and Fridays; there are not so much vehicles on other days of week therefore the average speed on Tuesdays, Wednesdays and Thursdays is higher in comparing with Mondays and Fridays (figure 4).

The average vehicle's speed in the particular stage of Riga's street is not stable; 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 5 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 Mondays and Fridays. This index changes on other days of the week such as Tuesdays, Wednesdays and Thursdays (figure 4).

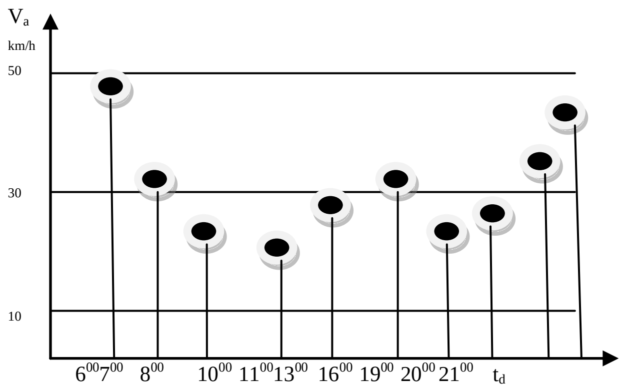


Figure 4: The Average Vehicle's Speed (Va).

Variables for Particular Crossroad in Riga in:

Particular Day's Hours (on Tuesday, Wednesday and Thursday).

Both mathematical 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 (Sprancmanis, 2003). For example, mathematical methods need fixed information about moving 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 combination.

3. Circular Route Planning: Vehicles Moving Time

Generally, it is possible to use only micro-elements method to improve route planning in cities with intensive and traffic. Some companies use a micro-element method to improve manufacturing process as well as to calculate actual costs of one production unit. To explain it we may investigate the following example.

It is useful to note, that the time of delivery consists of three basic positions:

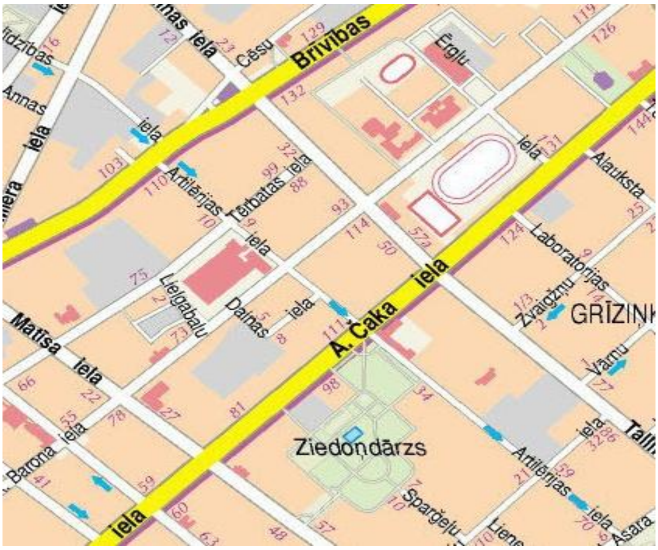
1. time of driving between crossroads;
2. time of driving through crossroads;
3. time of loading/unloading.

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 do 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. (figure5)

2. step. Notice, what is the average speed of driving at the particular hours for the each element. (figure5)

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



C 1 – Cu 9 – customer’s names

M[redacted]

Ot[redacted]

Figure5. Map of roads and customers location.

It is possible to divide roads into separated elements especially for “difficult” routes, included roads and crossroads with unstable and intensive traffic, which may vary many times per day.

Table 1 provides information about the average speed of vehicle for the particular part of Riga city roads depending on hours of a day. This data base makes easy route planning process for city with unstable traffic.

Sometimes unstable traffic is only in particular regions of city; in this case it is expediently to analyze only these “hard” places in details.

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

Hours of a day / The average speed	7-8 a.m., 8-9.p.m.	8-10 a.m. 4-5 p.m.	9-10 a.m. 5-6 p.m.	10-11 a.m. 6-7 p.m.	11-^{00}–14-^{00}
5km/h	C3-C7 C4-C5	C4-C5 C1-C9	C3-C7 C4-C5 C1-C9	-	-
5-10	C7-C6	C7-C6	C7-C6 C9-C5 C8-C5 C7-C9	C8-C5	-
10-15	C7-C9	C7-C9	-	C4-C5 C1-C9	C7-C6 C9-C5 C8-C5
15-20	C9-C5	C9-C5	-	C7-C6 C9-C5	C4-C5 C1-C9
20-25	C1-C9 C3-C4	C8-C5	-	C7-C9	C3-C7
25-30	C1-C2 C2-C4	-	-	-	-

For example, the average speed of vehicle, driving between C7 and C9 at 8-10 a.m. or 4-5 p.m. is 10-15 km/h.

It is quite long process to work out this data base, especially for big cities with developed infrastructure; specialists should spend a lot of time to complete it. Using this data base helps managers to plan vehicle’s moving time in optimal way. If the distance of the particular road’s element is known as well as if we know the vehicle's speed in this at the particular hour, we may plan the time; we spend to drive through this element.

It is expediently to create also the similar Time-Data-Base, analyzing particular periods of time, which we spent to drive between different customers or crossroads.

Sometimes it is necessary to create many data bases to improve vehicle driving planning time between crossroads or through crossroads.

Actually, 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.

4. Circular Route Planning: Vehicles Unloading Processes Time

It is possible to use formula (1), in order to achieve the best delivery time planning, it is necessary to improve planning of vehicle unloading time for each customer. For instance, if there are 50 customers within the particular route and the operator makes a 5 minutes 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);
- driver does not get in time serving customers during his working hours.

Both situations are not suitable 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:

- vehicle wait time (in a row) while other vehicles will be discharged by the particular customer. (T w)
- vehicle's maneuvering time by the particular customer.(T m)
- time needed for driver to get off from the cabin. (T off)
- time, needed for driver to go around vehicle. (T go)
- time, needed for driver to open vehicle's body. (T op)
- time, needed for driver to take a box with goods from the vehicle's body. (T t)
- time, needed for driver to carry the 1 box till a place, where customer receive it. (T c)

- time, needed for customer to check the cargo. (T ch)
- time to sign documents . (T s)
- time, needed for driver to return into the vehicle.(T r)
- vehicle's maneuvering time to drive out from customer's territory. (T ma)

Using formula2 may specify vehicle's unloading time.

$$Td = \sum_{i,j=1}^{n} tmij + \sum_{i=1}^{m} tui \qquad (1)$$

$$tui = T w + T m + T p + T off + T go + T op + T t + Tc + +Tch + T s + T r + T ma. \qquad (2)$$

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

IT is expediently to note, that there are 2 types of unloading time elements:

1).dependent on quantity of cargo T t+ Tc+ Tch;

2).independent on quantity of cargo T w+ T m+ T p+ T off+ T go+ T op +T s+ T r+ T ma.

It is possible to plan the first group time elements if we calculate how much time the driver need to take one unit of cargo from the vehicle and carry it to customer warehouse as well as to check it as well as know the volume of cargo for particular customer.

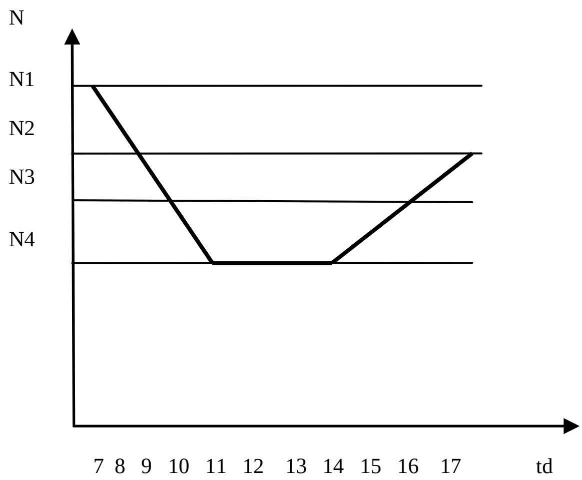
The second group's elements analysis is more complicated.

Planning vehicle wait time (in a row) Tw, manager has to know the number of other forwarders concentration for different clients. Usually the average number of forwarders, serving the particular customer simultaneously, varies depending on particular hours of a day. Products with shelf life are usually delivered in the morning or evening (figure 6).

Some warehouses' working time is being in progress day and night, but others works only till 5 or 6 p.m. Generally, caterers' concentration is different from 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.

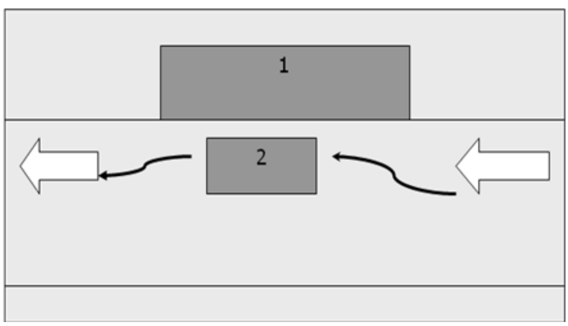
After this information is collected, it is essential to process it, creating a special system. It is possible to investigate wait (in a row) time by the each customer (figure 6) at the particular day's hours.

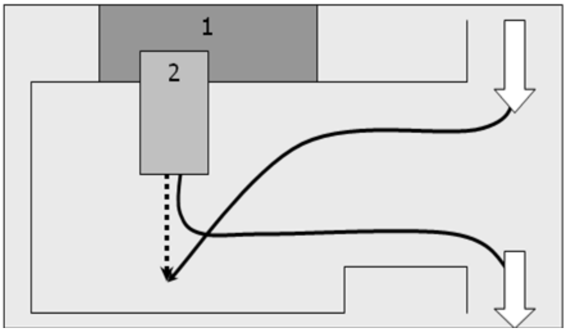


N – number of caterers.
Td – hours of a day.
Figure 6.Perishable goods caterers' concentration for particular customer.

According to the information of Figure 6, the highest concentration of perishable goods caterers is at 7-9 a.m. as well as 15-17 p.m. analyzing this information; operator may minimize whole unloading process planning time as well as make the total delivery planning process more precisely. It is necessary to improve delivery service quality as well as to reduce delivery costs in general.

Planning vehicle's maneuvering time by the particular customer (T m); it is expediently to divide customers depending on types of vehicle maneuvers before unloading process.





Reverse motion;
1- served object (customer);
2 – vehicle.
Figure7. Types of maneuvering near customers warehouse (example).

Different customers have different location of their warehouse. On the one hand, sometimes client and its warehouse located near road (figure 7a); in this case vehicle's driver will not pay a lot of time for maneuvering process (driver parks the vehicle near the customer and starts cargo unloading process). On the other hand, sometimes maneuvering process is more complicated; it consists of many elements and requires a lot of time to park a vehicle near the client.

For example, there are many cases, when maneuvering process includes also a reverse motion (figure 7b). It is necessary to plan precisely the total time needed for maneuvering process for different customers. Manager may divide served objects into some groups, depending on the types of maneuvering near them and create maneuvering-time data base to improve unloading time planning. Usually it is expediently to divide company's customers into approximately 5-7 types depending on the vehicle's maneuvering time near customer's warehouse.

Many other elements of the vehicle's unloading time tui are not so painful for planning. For instance, - time, needed for driver to park a vehicle T p depend on type of vehicle and place for parking near customer warehouse.

Time needed for driver to get off from the cabin Toff also depends on type or model of vehicle.

Time, needed for driver to go around vehicle T go – depends on the model and size of vehicle in general.

Time, needed for driver to open vehicle's body Top– also depends on the model and type of vehicle (refrigerator etc.).

Actually, manager may create one more data base combining unloading time elements T p+ T off+ Tgo+ T op for the each type/model of company's vehicles.

5. Conclusions

A circular route planning is a complex and significant problem for cities with intensive traffic. It is expediently to use micro-elements method, to improve routing process. Creation of roads elements average speed's data base as well as driving time data base makes route planning process easier. Usually it is useful to divide the time of delivery into three basic groups: time of driving between crossroads, time of driving through crossroads, time of loading/unloading.

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 row) time may vary for each customer depending on the particular hours of a day. Also vehicle maneuvering time near customers' warehouse may vary for different objects.

It is important to divide the total unloading time into separated micro-elements, as well as to create wait time data base, maneuvering types data base and combined unloading element data base(for different vehicles' models) in order to optimize unloading time control process for circular routes planning.

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