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CLARKE AND WRIGHT SAVING ALGORITHM AS A MEANS OF DISTRIBUTION STREAMLINING IN THE ENVIRONMENT OF A CONCRETE COMPANY

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Abstract: Reducing costs forces of companies to look for reserves also in field of management, support and implementation of material flow. This is connected with the optimization of costs for product distribution, which forms a significant part of the total cost of the company. In practice, it happens that making plans for distribution of materials within a distribution space is left solely to the implementers of distribution and it drivers of vehicles. As a result is uneconomic material distribution and unnecessary cost increases to his distribution. The objective of the paper is to propose a methodology for optimization of transport planning from DC Prešov to the individual Tesco units within the region that comes under this distribution centre. The methodology is based on the Clarke and Wright saving algorithm.

1 Introduction

The international retail chains entering the Slovak market and the competitive struggle for customers have introduced the need to open logistics and distribution centers in Slovakia, which is why optimization of distribution within the frame of logistics is a hot issue. Distribution of products is one of the main functions of Alfa Prešov distribution centre (hereinafter only DC Prešov) within the scope of Alfa Stores a.s. in Slovakia, and that is why improving of product distribution remains one of the opportunities leading to cost cuts in activities connected with distribution from the producers to the final consumers – customers [1]. The objective of the paper is to propose a methodology for optimization of transport planning from DC Prešov to the individual Alfa units within the region that comes under this distribution centre. The methodology is based on the Clarke and Wright saving algorithm.

2 Clarke and Wright saving algorithm

Alterations of methods and algorithms have led to the situation when various distribution parameters can be monitored at the same time, thus creating transport planes according to precise requirements of the customers and the system itself. The savings algorithm developed by Clarke and Wright in 1964 [2] seems to be the most suitable option from the viewpoint of speed and simplicity [3]. It is probably the reason of its wide utilization in commercial routing software systems (see e.g. [4]).

The algorithm results from a hypothetical arrangement of places *Sn* (where *n* is number of places), which are supplied from distribution centre *DCx*, according to figure 1. The initial plan of transports, which is gradually improving, lies in individual supply of each of the places. If we mark the distances of places (for example in kilometres) from the distribution centre as d_{xj}, the initial value of transported kilometres $z_{1,\dots,n}$ is calculated using formula (provided that $d_{xj} = d_{jx}$) [5]:

$$z_{1,\dots,n} = 2\sum_{j=1}^{n} d_{xj} \qquad (1)$$

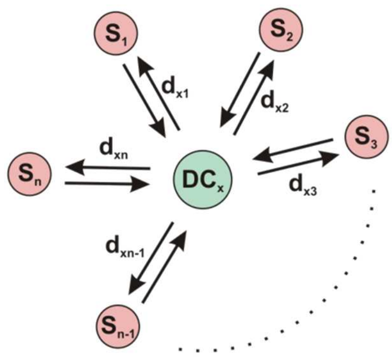
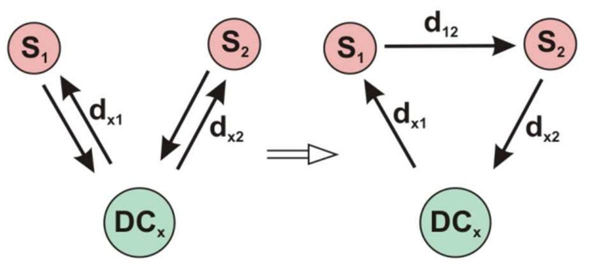


Figure 1 Arrangement of routes [5]

Maximization of savings that can be achieved if the individual places are gradually included into the circle is the criterion for creating the circle. If we, for example, replace the first two circles for a single one (Figure 2) and mark the distance between place S_1 and S_2 as d_{12}, we will obtain savings u_{12} in the amount of:

$$u_{12} = 2d_{x1} + 2d_{x2} - (d_{x1} + d_{12} + d_{x2})$$
$$u_{12} = d_{x1} + d_{x2} - d_{12} \qquad (2)$$



$$z_{12} = 2d_{x1} + 2d_{x2} \qquad z_{12} = d_{x1} + d_{12} + d_{x2}$$

Figure 2 Creating the circle for n = 2 [5]

If we generalize it, we can express the total savings $u_{1,\dots,n}$ as follows:

$$u_{1,\dots,n} = (d_{x1}+d_{x2}-d_{12})+(d_{x2}+d_{x3}-d_{23})+\cdots+(d_{xn-1}+d_{xn}-d_{n-1n}) = u_{12}+u_{23}+\cdots+u_{n-1n} \qquad (3)$$

The objective is to maximize the total savings $u_{1,\dots,n}$. The simple version of the Clarke and Wright saving algorithm rests in two steps:

1. Calculation of savings u_{ij}.
2. Selection of max (u_{ij}) if the connection is possible, i.e. if:

- The circle is not closed prematurely or.
- Other requests are not fulfilled, for example capacity ones.

Many variations on the savings algorithm have developed. Mole and Jameson [6] generalize the definition of the savings function. Altınel and Öncan [7] report enhancements due to Gaskell [8], Yellow [9], Paessens [10], Golden et al. [11], and Nelson et al. [12] and propose new saving criterion [13].

3 Analysis of distribution system in Alfa Company

DC Prešov was established because there was a need of more efficient supplying of Alfa business units (hereinafter only BUs) in Eastern Slovakia, and mainly because the distribution centre in Beckov had failed to cover the needs of all BUs in Slovakia. DC Prešov supplies Eastern Slovakia with fresh food goods named Fresh Food, and dry food and dry goods with a common name Ambient [1], [5]. There are 19 BUses in the region:

- Department stores: Košice, Prešov.
- Supermarkets: Svidník, Stropkov, Veľké Kapušany, Moldava nad Bodvou, Krompachy, Kráľovský Chlmec, Medzilaborce.
- Hypermarkets: Košice, Prešov, Poprad, Michalovce, Vranov nad Topľou, Rožňava, Humenné, Kežmarok, Prešov 3K (3000 m^2 sales area), Košice 3K (3000 m^2 sales area).

Alfa Company uses road vehicles for distribution of goods. The goods are transported on pallets. Transport plans are done by the Transport Department of DC Prešov. The employees from the department use their own knowledge and the empiric experience for transport planning. The planning system does not use any automatic mode [1], [5].

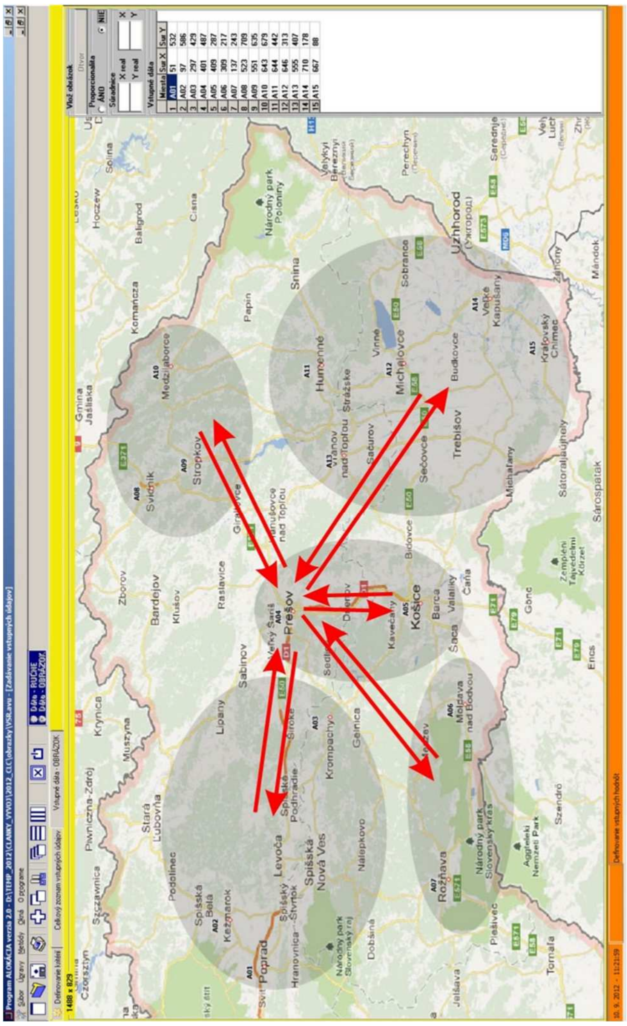


Figure 3 Quadrants of DC Prešov distribution region

The plans are put together using the orders from BUs on daily basis. Number of ordered pallets for the given day is the decisive criteria. Requests for pallets with Fresh Food have a priority before pallets with Ambient goods, which means the transports are planned in such a way to satisfy the requirements of BUs asking for fresh foods first. In case the capacity of the vehicle is not used up by Fresh Food pallets, we either add pallets with Ambient goods to be delivered in the same transport to the BU, or a combined delivery is created between 2 or more BUs with

Fresh Food pallets only, and then the requests for Ambient pallet types will be satisfied during the next transport which will be either direct, according to higher requested volume or, again, combined with other BUs [1], [5].

DC Prešov distribution region is divided into 4 quadrants (Figure 3). During the creation of combined transports only cities within a single quadrant are taken into consideration. BUses in Košice and Prešov have a special position. They are looked upon as intersections of quadrants in the distribution region and that is why they belong to each of the four quadrants. It means that in the combined transport plan within the frame of one quadrant we can also consider the option of combining BUs in Košice or Prešov.

4 Application of Clarke and Wright saving algorithm for solution of concrete problem with distribution

Proposed methodology is based on calculation of savings between individual BUs according to formula (2). Number of BUs is 19. Possible connections respect quadrants from figure 3. The calculated savings are organized in ascending order according to the amount of saved km (Table 1). Connections of BUs where the saved km equal 0 or less are excluded from the list, as it is irrelevant to think about combined transport in these BUs, because there are no saved km.

Table 1 List of savings between the individual BUses in km

List of savings u km														
Connection		km	Connection		km	Connection		km	Connection		km	Connection		km
3	6	206	6	18	71	4	14	26	10	14	11	11	15	6
10	15	172	4	6	70	8	14	25	12	19	11	11	19	6
3	11	145	2	14	68	2	6	23	1	18	10	2	15	5
4	13	139	6	8	66	12	13	23	9	16	10	2	18	5
10	13	132	3	18	66	4	12	22	4	9	10	3	10	5
13	15	121	3	13	65	10	16	22	12	15	10	6	16	5
11	14	118	1	14	64	8	12	21	14	15	10	6	19	5
3	14	117	11	17	64	18	19	21	14	16	10	7	9	5
6	14	117	3	4	63	9	10	19	1	8	9	7	10	5
6	11	116	3	17	62	15	17	19	5	16	9	7	16	5
7	14	107	11	18	62	3	5	18	5	19	9	3	15	4
2	7	95	3	8	59	5	11	18	8	9	9	7	19	4
12	14	92	11	13	59	9	15	17	1	5	8	2	8	3
1	2	91	4	11	58	9	19	17	1	13	8	2	19	3
1	7	91	7	12	57	10	19	17	1	17	8	7	15	3
17	18	91	8	11	57	10	17	16	9	12	8	11	16	3
13	17	90	2	11	54	1	10	15	12	16	8	2	5	2
11	12	88	2	3	53	10	18	15	1	4	7	2	9	2
13	18	88	4	10	46	5	6	14	1	9	7	2	13	2
4	17	86	1	12	41	9	13	14	1	16	7	2	16	2
5	13	86	4	5	40	15	16	14	1	19	7	2	4	1
3	12	85	5	17	40	15	19	14	2	17	7	6	10	1
4	18	84	5	18	39	8	10	13	3	19	7	16	17	1
5	10	83	1	11	37	15	18	13	5	12	7	16	18	1
7	11	83	1	6	36	16	19	13	5	14	7	5	7	0
8	17	83	1	3	35	9	17	12	6	9	7	6	15	-1
3	7	82	2	12	34	9	18	12	8	16	7	7	17	-6
8	18	82	4	15	34	17	19	12	8	19	7	7	18	-7
4	8	82	5	8	34	14	19	12	10	11	7	7	13	-8
8	13	82	14	17	32	13	19	12	13	16	7	4	7	-9
6	7	81	14	18	30	4	19	12	2	10	6	7	8	-10
5	15	81	1	15	29	10	12	12	3	9	6			
6	12	80	12	17	29	5	9	11	3	16	6			
6	17	77	13	14	28	4	16	11	9	11	6			
6	13	72	12	18	27	8	15	11	9	14	6			

The capacity of a transport vehicle is a limiting factor [1], [5], [14] when planning daily transports from DC Prešov to the individual BUs. The limit of vehicle capacity is 33 pallets. Daily requirements of the BUs regarding the number of pallets from DC Prešov vary. Larger BUs, mainly hypermarkets, requires several times more pallets than the capacity of the vehicle is. In such case, direct deliveries in these BUses with maximum utilization of the loading capacity of the vehicle are planned when the daily transport plan is being prepared [1], [5].

If the daily requirement of a concrete BU cannot be satisfied by direct transports using the maximum capacity of the vehicle, which means the request is not a multiple of 33 without any space left, a direct transport of 33 pallets will be scheduled and the remaining requested pallets will be included in combined transport planning process [1], [5].

With regards to the fact that there are days when some of the BUs, especially supermarkets, do not have any request for pallets from DC Prešov, the connections of these BUs must be excluded from the list of saved km. It is obvious that there is no need to visit the BU that day, i.e. include it in the transport plan.

It is convenient to exclude also connections of BU couples the combined requirements of which exceed 33 pallets, i.e. the vehicle capacity, from the list of km savings. It is obvious a combined transport to these couples of BUs cannot be planned.

The methodology can be summed up as follows:

1. Excluding the connections with BUs which have 0 pallet requests from DC Prešov for the following day from the list of km savings.
2. Specifying the direct transports with maximum utilization of vehicle capacity to those BUs requesting more than 33 pallets.
3. Including the remaining pallet requests of these BUses to combined transport planning.
4. Excluding the combinations of these two BUses the combined number of pallets of which exceeds 33 from the list of km savings.
5. Planning the combined transports according to the application of Clark and Wright algorithm.
6. Setting direct transports to these BUses the request of which is lower than 33 pallets but it was not possible to plan a combined transport to them.
7. Setting the sequence of realization of planned direct and combined transports according to the priority of Fresh Food.

5 Evaluation of Benefits

The main benefit of efficient distribution planning is an economic one. The costs of transportation represent one of the most significant cost elements in comparison with the other logistics activities in the distribution center. Efficient planning of distribution, with regards to economic factors such as price of fuels and labour, is very important when cutting the overall costs of transportation.

Daily transport plans in DC Prešov were monitored so as to quantify the economic benefits of the designed methodology. There were achieved these average daily results [1], [5]:

- Decrease of the number of transports by 10 %.
- Decrease of the number of km driven by 7 %.
- Decrease of consumption of fuels by 7 %.
- Increase in the capacity utilization of the vehicles by 9 %.

Another benefit which is not insignificant is the saved time. On one side, the time necessary for elaborating the daily transport plan is shorter and, on the other side, the time necessary for transporting the goods from DC Prešov to the individual BUs is shorter as well. Expressed in time when 1 km driven by a vehicle represents 1 minute, decrease in the number of kilometres by an average 186 km a day means approximately 3 saved hours a day.

Last but not least, there are also the ecological benefits. Reduction of the number of transports and the number of driven kilometres reduced the impact on the environment caused by motor traffic.

Conclusion

The designed methodology has brought mainly increased efficiency in the planning and distribution process, above all with regards to the time necessary for elaboration of such daily transport plans by using convenient information technology, such as software application designed for the needs of DC Prešov.

The benefits of optimized transport planning showed themselves in the economic area connected with distribution, namely in lower number of kilometres driven during the daily transports. This methodology results from the conditions and possibilities of the DC Prešov, but, through small modifications it can be used to optimize distribution in other distribution centres run by Alfa Stores a.s., not only in Slovakia.

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