PROPOSAL OF RECONSTRUCTION OF POSTAL TRANSPORTATION NETWORK

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Summary: The paper deals with the reconstruction of postal transportation network, specifically in Těšín and Třinec region. The reconstruction itself is a part of the centralization of delivery service which is to be implemented with using most modern technology and modern optimization methods. The existing postal network is not uniform and does not show elements of flexibility. The task of centralization of the delivery service is to find a balance in the system and create a network which will in effect form a flexible network, and of course will bring savings. The article describes the optimization methods that are suitable for creating a new and effective service system. Then these methods are applied to specific examples. It is important to note that proposal of reconstruction of postal transportation network concerns only service of packet segment.

Key words: centralization, depot, delivery area, postal network

1. INTRODUCTION

Year 2011 is for Czech Post, s. e. (hereinafter referred to as CP) one of the key years. As a result of the planned liberalization in 2013 the company is preparing changes that affect not only its trade but also its logistic activities. The target state of Czech Post logistics is the system reconstruction of postal network. The most modern technology and modern optimization methods will be used for this purpose.

Centralization itself is essentially a toll for optimizing delivery service, specifically packet segment. This should generally be carried out as follows: mapping the territory, appropriate location for the depots to the postal network, preliminary draft of the postal network and comparison of individual districts workload with the set standard. In the case of above-average workload it is necessary to return to the beginning of the proposal a rework it. Contrarily if the workload is below average, it would be appropriate to complement the action of post worker of packet segment by other activities. For example: delivery of letters or providing collection and distribution of postal material.

As an example of practical application of the proposed optimization procedure, it describes the optimization of the Severovýchodní Morava (North-East Moravia) that is one of the most problematic regions with regard to its size and location.

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2. ANALYSIS OF THE CURRENT STATE OF DELIVERY SERVICE

Delivery service includes both consignment delivery and issue. It must be organized in order to ensure fast, accurate and regular delivery of consignments addressed to the delivery area of a delivering post office. The region, where the state of delivery service is studied, belongs to the region Severní Morava (North Moravia). This region covers a total of 30 post offices, 5 managing post offices, 20 satellite post offices and 5 separate post offices.

Prior to the proposed redevelopment of the transport network it is necessary to analyze service delivery. This can be performed in two plans. One of them is an analysis of the postal network, where it is necessary to focus on the kilometers passed and especially the structure and properties of an delivery area. The second plan is cost analysis which examines in particular those cost items related to delivery service.

2.1 Defining the problem of Postal Technology, focusing on delivery service

The area of determining the optimal number of automated parcel centers (hereinafter referred to as ABD) is most important as it optimizes the transport network. Delivering consignments to the customer directly from the sorting centre (hereinafter referred to as SPU) is uneconomic with the current structure and volume of consignments. On the other hand a large number of ABD has many problems of which one is the utilization of some ABD. More than half of these centers are so-called small workplaces that process very small number of consignments. There are some space problems for example inadequate handling area, inadequate access road and precinct that previously served for other purposes. Most of these small centers are located in the heart of the city and therefore it is problematic for higher capacity vehicles to get there. Moreover, ABD have insufficient places for the consignment exchange, inadequate ramps, entrances to the yard, etc. Under such conditions Czech Post has to have lower capacity vehicles in its fleet if converted into one consignment, which is economically disadvantageous.

2.2 Definition of postal transport network in Těšín and Třinec region

The postal network is divided into three transportation networks: main, regional and purpose transportation network. The main transportation postal network connects each SPU from the whole Czech Republic. Only posts with an automated parcel centre, namely Český Těšín 1, Bystřice nad Olší, Třinec 1, Hnojník a Jablunkov, are involved in the regional transportation network of the considered region. Each post must be served by a postal vehicle at least twice a day. However, the actual participation is much higher. One of the drawbacks is that not all posts are handled directly from the sorting centre. But the postal vehicles come from other parcel centers which are included in their timetable. Selected regions are thus served by a total of 13 postal vehicles which daily drive up to 1766 kilometers.

The purpose transport network involves 25 posts. The consignments are collected by the local purpose transport network and forwarded to ABD and then to SPU by the regional transport network. The post offices which constitute so called centers of the regional transport network perform some activities for the post offices that are connected to them. The operation is ensured by 44 delivery areas. The post workers in such network drive up to 2289 kilometers every day.

2.3 Cost analysis of the selected region

The delivery service costs include labor costs and vehicle maintenance and operating costs. The labor costs at Czech Post are almost 75% of all costs. In the analyzed region the amount in 2009 was 70 618 455 CZK. The labor costs depend on number of workers (in the region) and type position of a postal employee. The position of a post worker represents the highest number of CP employees not only in this region but also in the CP statewide. The number of delivery areas influences this particular number provided that each post worker operates in one delivery area. The total number of the post workers is not final as it is greater than the number of delivery areas. It is necessary to have so-called inverter officers who substitute the post workers who are ill or on holiday leave.

Each managing post has a rental fleet by which means it operates the region. The simplest way to assess the cost of operation is to monitor fuel costs, given the mileage and the number of vehicles. The calculation revealed that the daily fuel costs for the given region are 9 381 CZK.

3. APPROPRIATE METHODS FOR OPTIMIZING THE POSTAL NETWORK

The proposal of reconstruction of the transportation postal network concerns especially the regional and the purpose postal network. The basic element of the transportation network is SPU which serves as a sorting centre. In 1993 the transportation postal network consisted of 19 SPU but even those were closed down. Targeted reduction of the network resulted in the reduction to 11 SPU in 2008 and an optimal state in year 2013 appears to be 8 SPU (or 5 SPU). The decision on the final state of the SPU is apparently quite difficult as well as the preparation of the postal network reconstruction that is also related to the segment of letters. The segment of the letters does not include only letters but also retirement pension, promotional materials delivery, postal order delivery and etc. In this case, the change would affect not only the postal network but also the operating regulations.

When solving the tasks of optimization the transportation postal network can be displayed by means of graph theory. From the mathematical viewpoint the transportation network represents a graph which consists of a set of vertices (the post offices) and a set of rated edges (possible routes between the posts having a certain length). This information is crucial for solving so-called orbital transportation problem. Before problem solving proceeds it is necessary to locate a position of the center (the depot) in the graph (network). To locate a position of the depot Floyd's algorithm can be used. This algorithm serves to search for distances in transportation network that is presented by means of the graph and is based on the comparison of direct and indirect distances. Before moving to determination of the delivery areas route, it is important to determine the number of delivery areas. For this purpose the method of multicriteria decision is convenient. The first step is to determine weights for each criterion of evaluation which expresses the numerical importance of these criteria. For the needs of the paper Saaty's method was chosen. This method determines the preference of the individual criteria which are expressed by the number of points from the selected scale. The

geometrical mean of the Saaty's matrix is used to obtain the weights of the criteria. Then the normalization of the geometric mean is applied.

The method of linear partial utility function is chosen to determine the optimal method. This method distinguishes between qualitative and quantitative criteria. After calculating all partial evaluations, the results are multiplied by respective weight. This way we obtain the values that determine the optimal option - the maximum value is chosen. This method is chosen as it helps to reduce subjectivity in the determination of partial evaluation options.

If the depot is located in the postal network and the optimum number of delivery areas is determined (which will provide servicing of a selected area), it is appropriate to return to the orbital traffic problem. Little's algorithm serves the purpose of finding the minimum Hamilton's circles of the graph. Hamilton's circles represent the role of a commercial traveler who must visit all the places (tops of graph), each place is visited once and then the traveler returns to the initial location. His total distance will be minimal. The Little's algorithm is a tool. By the means of this tool, the route of each delivery area will be created in a way that the distance which the parcel post worker passes will be minimal.

4. PROPOSAL OF PROPOSED OF DELIVERY SERVICE CENTRALIZATION IN TĚŠÍN AND TŘINEC REGION

The objective of the optimization is cost reduction and quality maintenance, delivery service to remote communities and safety of post workers. Within delivery area of the managing posts it is necessary to implement reconstruction in the following way: transfer of the vehicles to the depot, reorganization of the existing motorized and pedestrian post workers of service delivery, establishment of parcel delivery areas for localities where the delivery service cannot be ensured by motorization, eventual creation of the independent network for advertising and promotional material.

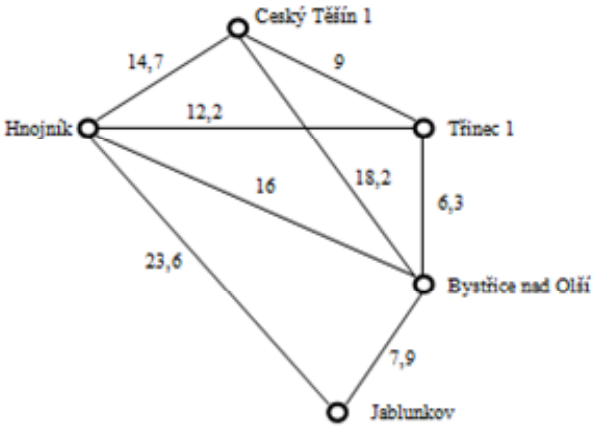
Further step of reconstruction is to focus on maximum utilization of vehicles, i. e. the increase in the form of distance and hourly load vehicles, using the vehicles within the delivery route and other activities by which means it will minimize the number of duplicate runs. In rural, and especially in the foothill areas it is necessary to focus on the motorized delivery which implements delivery service of parcels and letters together on one run.

4.1 Starting point of proposed centralization

The first important step for the centralization of delivery service is the location of a depot in analyzed area. This depot will be the starting point for delivery service and it will replace existing parcel centres in its area. The postal vehicles that implemented the collection and distribution from these posts to SPU will be cancelled. The direct connection between SPU Ostrava and the depot will come to existence. This step will remove the duplicate runs which are unsatisfactory due to rising costs.

The graph theory can be used to optimize the location of the depot in the locality. By means of Floyd's algorithm a place on a map can be found from which the arrivals from allocated posts will be reduced to a minimum. The base for calculation is a graph (Fig. 1)

which simply shows the road network. It means all the possible connections between the management posts and their distances in kilometers.



Source: Authors

Fig. 1 - The road network between the management posts

On the basis of the data from Fig. 1 a matrix of distance can be created and then Floyd's algorithm can be applied to the matrix. For simplicity of the matrix the names of the towns/cities will be replaced by the serial number. This means that Český Těšín will be peak v_1, Hnojník v_2, Třinec v_3, Bystřice nad Olší v_4 and the last v_5 Jablunkov. The default matrix, for the Floyd's algorithm, corresponds to Tab. 1.

Tab. 1 - The default matrix for the Floyd's algorithm

	v_1	v_2	v_3	v_4	v_5
v_1	0	14,7	9	18,2	∞
v_2	14,7	0	12,2	16	23,6
v_3	9	12,2	0	6,3	∞
v_4	18,2	16	6,3	0	7,9
v_5	∞	23,6	∞	7,9	0

Source: Authors

The procedure of the Floyd's algorithm is as follows: gradually introduce the variable until the k = 5. An example is given on calculation for the variable k = 2. In the following matrix the second row and column are marked as they both correspond to this step. (See Tab. 2).

Tab. 2 - The Floyd's algorithm - the variable k = 2

	v_1	v_2	v_3	v_4	v_5
v_1	0	14,7	9	18,2	∞
v_2	14,7	0	12,2	16	23,6
v_3	9	12,2	0	6,3	∞
v_4	18,2	16	6,3	0	7,9
v_5	∞	23,6	∞	7,9	0

Source: Authors

The elements in the matrix are converted according to the following rules: $c_{ij} = \min\{c_{ij}, c_{ik} + c_{kj}\}$. The first possible element which can be converted there is an element c_{15}. After the substitution in an equation the result is the following: $c_{15} = \min\{\infty, 14,7 + 23,6\}$. It is clear that $38,3 < \infty$ and thus the value of the element changes from ∞ to 38,3. The same procedure applies too to the following elements of the matrix. The procedure for converting elements of the matrix varies depending on the variable k and if k = 5, calculation is terminated and the last matrix is the resultant matrix. In each row the maximum value is selected and out of these values the minimum value is selected. The resultant matrix is shown in Tab. 3.

Tab. 3 - The resultant matrix Floyd's algorithm

	v_1	v_2	v_3	v_4	v_5	max
v_1	0	14,7	9	15,3	23,2	23,2
v_2	14,7	0	12,2	16	23,6	23,6
v_3	9	12,2	0	6,3	14,2	14,2
v_4	15,3	16	6,3	0	7,9	16
v_5	23,2	23,6	14,2	7,9	0	23,6

Source: Authors

After applying the calculation of Floyd's algorithm the town of Třinec is marked as the optimal starting point for delivery service. This depot will be involved in the postal network directly. That means the permanent route from Ostrava. The advantage is the possibility of replacing smaller trucks with larger trucks which could reduce the number of involved posts to the regional postal network.

4.2 Determination of optimum number of delivery areas

One of the steps of the proposed changes in the postal network is to replace the solid delivery area of a post worker by a new dynamic delivery area. This district is a subset of deposited places which allow the delivery of the expected number of parcels by one vehicle within one working day of a postman. Several aspects affect the number of delivery areas. This is essentially a crossing between the villages within one delivery area, the number of deposited places, capacity of vehicles and working hours of a postman.

Determination of optimum number of delivery areas can be based on a managerial decision-making method. This method is optimized and takes into account all criteria which have impact on particular possibilities. The possibilities in this case will be potential number of delivery areas. The basis for determining possible options is the ratio between the planned volume of the consignments to be processed in the respective depot, namely 1450 consignments, and the maximum possible number of consignments that can be handled by post workers; it is 125, 100, 90 and 80 consignments.

For the calculation it is also important to establish criteria including their weights. For the purposes of this proposal the following criteria were determined: kilometers passed, delivery area utilization and costs of the post workers. For the purpose of establishing the weights of these criteria Saate's method was chosen. This determines the size of preferences of the individual criteria which reflect the number of points from selected point scale (which

is given). The preferential relationship is determined on the basis of data obtained from the expert estimates. The resultant Saate's matrix has the following form, see Tab. 4.

Tab. 4 - Saate's matrix

	K1	K2	K3	G_i	G_i'
K1	1	0,33	0,2	0,4	0,12
K2	3	1	5	2,5	0,65
K3	5	0,2	1	1	0,26

Source: Author

After determining the weights it is appropriate to apply the method of the linear partial utility function which serves to determine the optimal variant. The optimal variant is real number of delivery areas. The first step of this method is to calculate the partial evaluations. The specified criteria are quantitative and costly. It is therefore necessary for the conversion to use the following relation:

$$h_i^j = \frac{x_i^0 - x_i^j}{x_i^0 - x_i^*} \qquad (1)$$

explanatory: h_i^j the partial evaluation,
x_i^j the value of elements in the matrix,
x_i^0 worst value of criteria,
x_i^* best value of criteria.

After calculating all partial evaluations, the results are multiplied by respective weight. From thus obtained value is selected the maximum value. This value determines the optimal variant of number of delivery areas.

Tab. 5 - The resultant matrix of method of linear partial utility function

	V1	V2	V3	V4
K1	0,59	1,00	0,43	0,00
K2	0,00	0,56	0,81	1,00
K3	1,00	0,57	0,29	0,00
	0,331	0,634	0,655	0,650

Source: Authors

The result of the method of multicriteria decision is the third alternative. That means 17 delivery areas represent optimal variant.

4.3 Route location of delivery areas

If the number of the delivery areas is known, the next step of the proposal is route-location. The postman is obliged to visit each location (city or municipalities) only once and return to the depot in order to ensure that the total travelled distance will be minimal. For the calculation of the route Little's algorithm is used. The division of cities and municipalities in the delivery areas is performed by empirical method namely by means of observation method.

The initial basis for the Little's algorithm is the distance matrix. As an illustrative example the delivery area is chosen whose vertices are: Český Těšín 6 (v_2), Mistřovice (v_3) a Koňakov (v_4). The top of the graph v_1 is depot Třinec. The postman will leave this depot to conduct his delivery route and after the end of the delivery route will return to the depot. The default distance matrix is following, see Tab. 6.

Tab. 6 - The default matrix Little's algorithm

V	v_1	v_2	v_3	v_4
v_1	∞	14	15	15
v_2	14	∞	2	∞
v_3	15	2	∞	2
v_4	14	∞	2	∞

Source: Authors

When applying the process of Little's algorithm the elements of the default matrix are reduced. At the end of the calculation the matrix has the following form, see Tab. 7.

Tab. 7 - Little's algorithm - the resultant matrix

V	v_2
v_3	0

Source: Authors

The result of the calculation is the creation of the direction of the delivery route which has minimum kilometres passed. In this particular example the delivery route is as follows: depot Třinec - Koňakov - Mistřovice - Český Těšín 6 - depot Třinec. The postman on his delivery route passes the total of 24 kilometres. The following delivery areas are converted in the same way, see Tab. 8.

Tab. 8 - Little's algorithm - the delivery areas

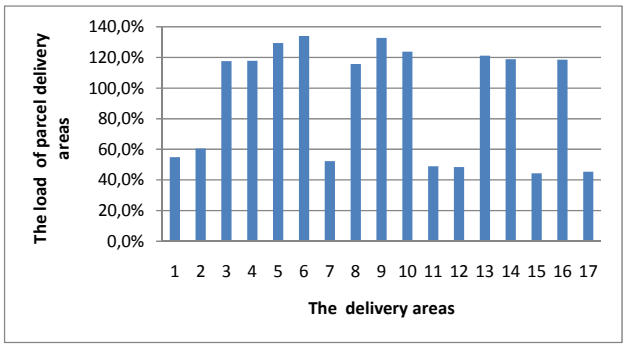
	Municipalities	kilometres passed		Municipalities	kilometres passed
1.	Horní Lomná, Dolní Lomná	50	10.	Nýdek, Bystřice	23
2.	Mosty u Jablunkova, Hrčava	48	11.	Milíkov, Bocanovice	36
3.	Třinec 9, Horní Líštná, Vendryně	19	12.	Tyra, Guty, Řeka	32
4.	Třinec 1, Třinec 3, Kojkovice	15	13.	Písečná, Bukovec, Písek	39
5.	Třinec 4, Třinec 5, Třinec 8, Třinec 11	18	14.	Horní Žukov, Dolní Žukov, Český Těšín 7	28
6.	Český Těšín 1, Český Těšín 3	30	15.	Český Těšín 6, Mistřovice, Koňakov	24
7.	Chotěbuz, Stanislavice	38	16.	Smilovice, Střítěž, Vělopolí	24
8.	Horní Tošanovice, Dolní Tošanovice, Třanovice	28	17.	Komorní Lhotka, Hnojník	22
9.	Jablunkov, Návsí, Hrádek	36			

Source: Authors

At first sight it is evident that the amount of kilometres passed is really minimal. But this number is not final because it involves only crossing between the municipalities and the depot. To those kilometres passed it is still necessary to add the amount of miles which the postman passes in each municipality - from one delivery place to another.

4.4 Load of delivery areas

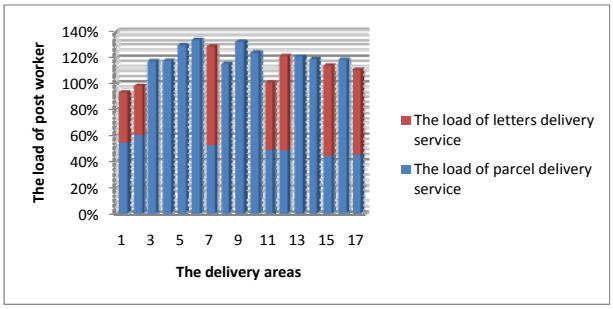
Provided that the number of delivery areas is known, the following step is most important. The important step is the calculation of the load which is dependent on the amount of working and shift time and also so-called "norm minutes". The individual delivery areas should have a comparable load. This is only possible if the delivery areas have the same conditions. In fact, this is not valid, each delivery area is different. The load of 17 delivery areas is graphically illustrated in figure 2.



Source: Authors

Fig. 2 - The real load of parcel delivery areas

The above mentioned graph shows the below-average load of some delivery areas. To increase the load of delivery areas so-called motorized delivery can be used. This is a combination of letters and parcels delivery. After recalculating the load of the letters the graph will have the following form, see Figure 3.



Source: Author

Fig. 3 - The load of motorized delivery areas

Now we can read from the graph (Fig. 3) the above-average load of all delivery areas. It would therefore seem that the proposal is not real and the postman is unable to implement it. But it is important to realize how the load is set in terms of Czech post. It must be remembered that the delivery area is fully occupied if the load is in the range of 110-130%. At this point it is necessary to consider whether Czech post standard for delivery should not be revised in order to ensure more realistic standard. If the load was still the above-average load after eventual revision of standards we could carry out several possible options. One way to reduce the load of motorized delivery areas is that the delivery service of one motorized district could be performed by two post workers given that their delivery areas would be flexible. Therefore the two post workers can handle consignments of other delivery areas or may deliver to businesses that receive a large number of consignments. Another option is to use so-called "fictitious business delivery areas".

4.5 The proposal for the collection and distribution of postal items

It must not be forgotten that with the concentration of all postal routes to Třinec depot the service of posts in regional and purpose transportation network ceases. And it is very important to maintain those activities because the postal routes provide collection and distribution of the postal consignments and cash allocations. Newly the collection and distribution is provided by a postman of motorized delivery areas or a postman of so-called "fictitious business delivery area". This delivery area is proposed specifically for this activity.

5. CONCLUSION

The effort of the Czech post is to increase efficiency of main activities. One way of ensuring this is through a flexible postal network. The proposal assumes reducing annual costs of 1 kilometre by 50% and reduces annual labour costs by 5%. The summary of annual savings is compared with the costs of investment which is 48 055 842 CZK. The actual

savings is not a suitable basis for the decision to implement the proposal. It is important to calculate the efficiency of the investment. For this purpose the two methods were selected: the payback period and the method of net present value. The results of both methods are the same: the investment is effective. It is clear that the proposal is feasible in economic terms.

The proposal is possible only if the Czech Republic is served from 8 sorting centres and on condition that only post workers delivering parcels will perform errands from Třinec depot. In this case parcel delivery areas will be substituted by motorized delivery areas.

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