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CAR SCRAP YARDS NETWORK IN SLOVAKIA

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ABSTRACT

The paper is focused on specific location-allocation problem aimed to determine a set of scrap yards for vehicle decommissioning in Slovakia. The goal is to determine scrap yards network so that it is not prohibitive to pass old car for dismantling and further processing wherever former owner lives. Two approaches are considered. Once we consider the case when it is necessary to construct a completely new network of scrap yards, which results to setting of their minimum numbers and also their location. In the latter case, the already existing network of scrap yards is considered, while the model provides its extension, in order to achieve the desired values of accessibility for all residents. The results were applied to an existing network of scrap yards identifying locations to build new scrap yards. Areas where whole new network of scrap yards must be built were also identified.

Keywords:
car scrap yards, optimization, location problems, mathematical programming

JEL: C02, C61

INTRODUCTION

Presently the reaching of environmental goals takes an increasing emphasis on waste recycling. A major problem encountered in any process of collecting and remanufacturing of raw materials is the availability of collection points respectively sorting centers for recyclable waste (namely scrap yards in the case of vehicle decommissioning). According to 2012's Eurostat statistics, in the EU's inhabitant annually produces an average of almost 500 kg of municipal waste, in Slovakia it is approximately 320 kg. In Slovakia almost 74% of it goes to landfill municipal waste and only rest will be recovered while in more developed countries, this ratio is reversed. One of the reasons for the low interest of Slovak citizens in the collection of secondary raw materials is also the location of collection points for recyclable waste.

The paper deals with partial waste recycling problem, namely vehicle decommissioning in the scrap yards. Although the disposal of used cars in scrap yards is obligatory for the population, it is clear, that without adequate accessibility of scrap yards it is not possible to achieve maximum impact when disposing of used vehicles.

One of the actual challenges in Slovakia is to build a transparent and current information system to map the flow of secondary raw materials. The current system is often inaccurate and incomplete and it is clear that without adequate availability scrap yards is not possible to achieve maximum impact when disposing of used cars. The system should not be directed only to monitor the flows of secondary raw materials, but also to their optimization.

The paper is focused on the model aimed to solve the location-allocation problem. The goal is to determine a set of collecting points (scrap yards) so that it is not prohibitive to pass old car for dismantling and further processing wherever former owner lives. Two approaches are considered. Once we consider the case when it is necessary to construct a completely new network of scrap yards, which results to setting of their minimum numbers and also their location. In the latter case, the already existing network of scrap yards is considered, while the model provides its extension, in order to achieve the desired values of accessibility for all residents.

Modelling of car scrap yards network represent designing of large public service systems. Designing of public service system includes determination of center locations, from which the associated service is distributed to all users of the system, e.g. [Current, Schilling (2002), Ingolfsson, Budge, Erku (2008)]. It can be assumed that the number of service centers must be limited due to economic and technological reasons [Janáček, Linda, Ritschelová, (2010)]. The public service system structure (also car scrap yards network) is formed by deployment of limited number of service centers and the associated objective to minimize the social costs, which are proportional to the distances from users to the nearest service centers. The standard approach to the public service system design assumes that the user is served from the nearest located service center or from the center, which offers the smallest disutility to the user [Janáček, 2015].

Different works aimed at various location problems can be found, e.g. [Brezina, Pekár, Čičková (2009), Brezina, Dupaľ, Pekár (2011), Drezner at al. (2004), Jánošíková, Žarnay (2014), Pekár, Brezina, Čičková (2010), Pekár, Brezina, Čičková (2016), Eiselt, Sandblom (2004)]. The primary objective is faster deployment of scarp yards; this objective can be achieved using the location model when determining the minimal number of scarp yards as well as maximal accessibility is given.

1. LOCATION-ALLOCATION PROBLEM WHEN MAXIMAL ACCESSIBILITY IS GIVEN

This section describes a model that enables to determine the number of scrap yards if the maximum distance that residents have to travel to the nearest of it is given, e.g. [Brezina, Pekár, Čičková (2009), Pekár, Brezina, Čičková (2016)]. The aim is to locate scrap yards in Slovak towns or municipalities with more than 2500 inhabitants (the number of such towns and municipalities in Slovakia is presently 302)) so that the required accessibility (we will proceed to consider distances 50, 40 and 30 km) while pursuing the goal of minimizing the number of scrap yards. Next, the mathematical location-allocation model is given.

The situation can be described by binary programming problem, when we consider the binary variables $x_j \in \{0,1\}, \quad j = 1, 2, \ldots n$, where n represent the number of municipalities (and towns) in Slovakia. The meaning of those variables is following: if the variable $x_j = 0$, the scrap yard is not built in j-th municipality or $x_j = 1$ otherwise.

Let Pj be the number of inhabitants of j-th municipality. The whole number of inhabitants is

$$P = \sum_{j=1}^{n} P_j, \quad j = 1, 2, \ldots n$$

Than it is possible to calculate the coefficients c_j: $c_j = 1 - \frac{P_j}{P}, \; j = 1, 2, \ldots n$

The coefficients represent the potential number of requests coming to the scrap yard. Than the objective can be written as follows:

$$f(x) = \sum_{j=1}^{n} c_j x_j \rightarrow \min \tag{1}$$

Now we introduce the other parameters of the model. Let K be the scalar value that represent the maximal desired values of accessibility to the nearest scrap yards and let be the parameters that represent the minimal distances between the municipalities *i* and *j*, $i, j = 1, 2, \ldots n$. Now the parameters can be set as follows:

$$a_{ij} = \begin{cases} 0, d_j > K \\ 1, d_j \leq K \end{cases} \quad i, j = 1, 2, \ldots n \tag{2}$$

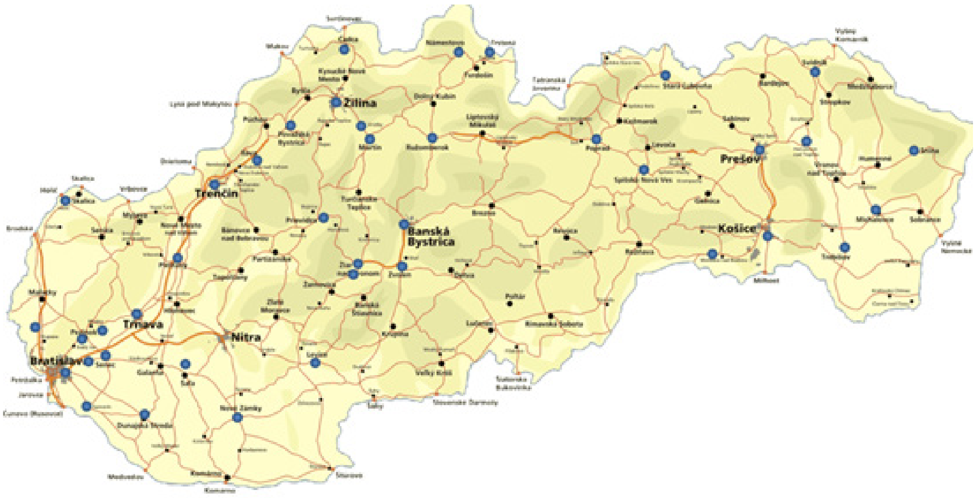
where $a_{ij} = 0$ if the distance between i-th and j-th municipality is lesser than K and $a_{ij} = 1$ otherwise. Based on (2) it is possible to construct the equations that ensure the availability of the municipalities from at least one scrap yard in maximum distance K.

$$\sum_{j=1}^{n} a_{ij} x_i \geq 1 \;, i = 1, 2, \ldots n \tag{3}$$

2. SCRAP YARDS NETWORK IN SLOVAKIA WHEN MAXIMAL ACCESSIBILITY IS GIVEN

The current situation of location of scrap yards in Slovakia is location in 40 municipalities – Figure 1 – (some larger towns or municipalities have more than one scrap site): Zohor, Bratislava – Ružinov, Bernolákovo, Pezinok, Šenkvice, Trnava, Senec, Šamorín, Dunajská Streda, Holíč, Piešťany, Nové Zámky, Močenok, Dubnica nad Váhom, Trenčín, Hliník nad Hronom, Levice, Prievidza, Žiar nad Hronom, Považská Bystrica, Zvolen, Banská Bystrica, Spišská Nová Ves, Turňa nad Bodvou, Poprad, Stará Ľubovňa, Prešov, Košice – Juh, Hanušovce nad Topľou, Trebišov, Michalovce, Svidník, Snina, Čadca, Námestovo, Trstená, Žilina, Vrútky, Martin, Ružomberok (if a scrap yard is built on a site with less than 2500 inhabitants, it is assigned to the nearest city or municipality with more than 2500 inhabitants).

Figure 1. Location of existing scrap yards



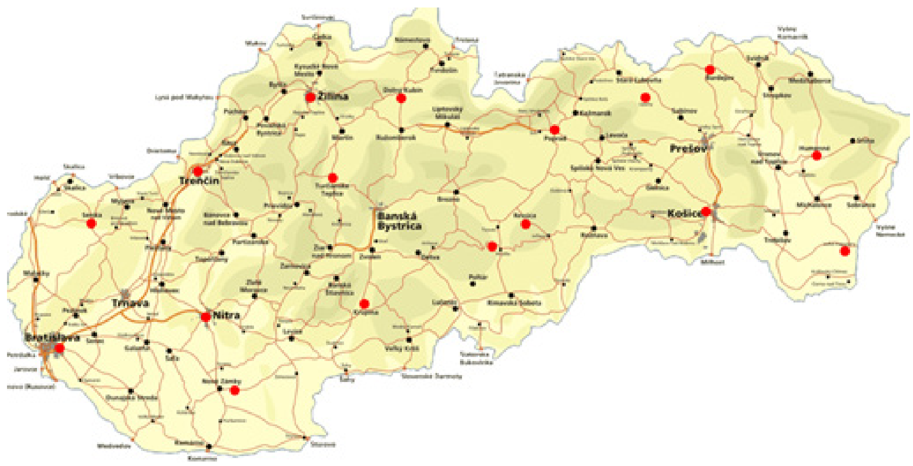
existing location of scrap yard

Based on above model consider the following two problems:
1: to construct a completely new network of scrap yards, while considering given desired values of accessibility for all residents (only in Slovak towns or municipalities with more than 2500 inhabitants)
2: to extend existing network of scrap yards, while considering given desired accessibility values for all residents (only in Slovak towns or municipalities with more than 2500 inhabitants)
The specified maximum distances (K) are set to 50, 40, and 30 km.

Strategy A: Location at a maximum distance of 50 km

1. Results (a completely new network of scrap yards)
When considering the 50 km accessibility than the minimal number of scrap yards is 17. Their location is illustrated in Figure 2.

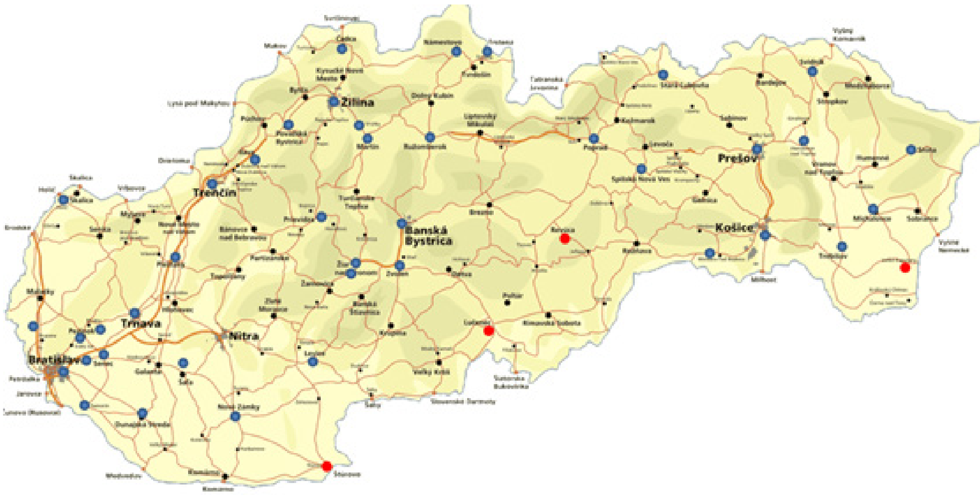
Figure 2. Location of new scrap yards – Strategy A



new location of scrap yard

2. Results (extension of an existing network of scrap yards)
When considering the 50 km accessibility with respect to existing network scrap yards network than the minimal number of scrap yards is 44 (40 existing and 4 new location). Their location is illustrated in the Figure 3.

Figure 3. Extension of an existing network of scrap yards – Strategy A

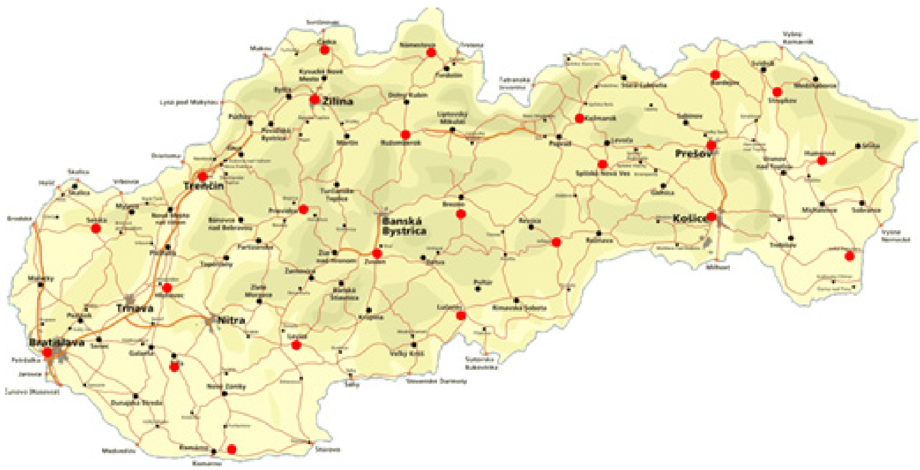


●	new location of scrap yard
●	existing location of scrap yard

Strategy B: Location at a maximum distance of 40 km

1. Results (a completely new network of scrap yards)
When the accessibility is reduced to 40 km than the minimal number of scrap yards is 24. Their location is illustrated in Figure 4.

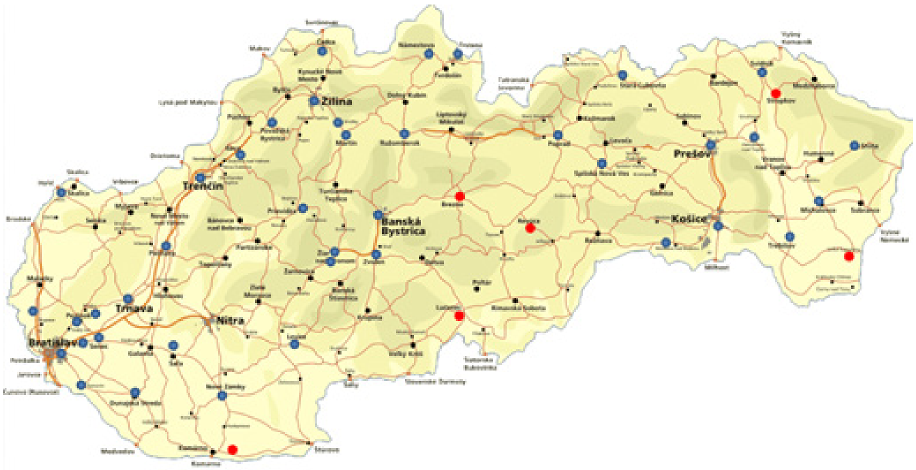
Figure 4. Location of new scrap yards – Strategy B



●	new location of scrap yard

2. Results (extension of an existing network of scrap yards)
When the accessibility is set to 40 km with respect to existing scrap yards network than the minimal number of scrap yards is 46 (40 existing and 6 new location). Their location is illustrated in the Figure 5.

Figure 5. Extension of an existing network of scrap yards – Strategy B

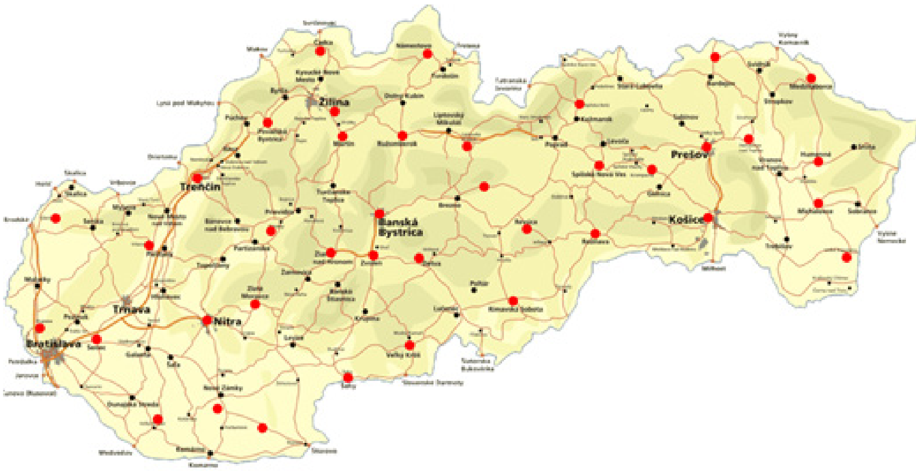


●	new location of scrap yard
●	existing location of scrap yard

Strategy C: Location at a maximum distance of 30 km

1. Results (a completely new network of scrap yards)
When the accessibility is reduced to 30 km accessibility than the minimal number of scrap yards is 39. Their location is illustrated in Figure 6.

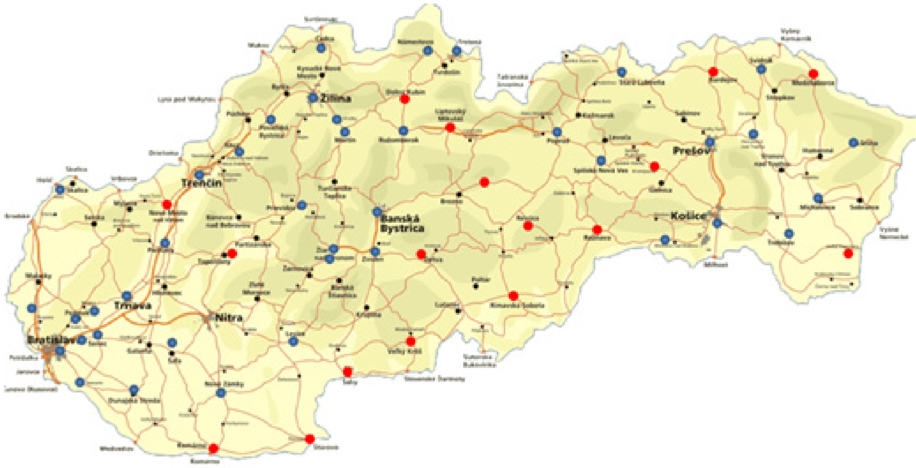
Figure 6. Location of new scrap yards – Strategy C



●	new location of scrap yard

2. Results (extension of an existing network of scrap yards)
When the accessibility is set to 30 km accessibility with respect to existing scrap yards network than the minimal number of scrap yards is 57 (40 existing and 17 new location). Their location is illustrated in the Figure 7.

Figure 7. Extension of an existing network of scrap yards – Strategy C



	new location of scrap yard
	existing location of scrap yard

CONCLUSION

Besides an existing legislation, there must be built a network of available scrap yards when one wants to increase the interest in the environmentally disposal of waste. When collecting old cars, this can be achieved by optimizing the minimum scrap network, which can be adjusted based on their distance from the dwellings of Slovak residents. The minimum scrappage network ensures real availability for all residents at a given maximum distance. In the current situation there are already 46 scrap yards in 40 locations. When looking at the SR map (Figure 1), however, they are unevenly distributed, as the maximum accessibility is currently 87 km (scrap yard in Zvolen and the inhabitants of Rimavská Sobota).

When considering a maximum availability of 50 km, building up a completely new network requires creating 17 new scrap yards (their location is given in the previous section). In the case of completion of existing network with respect the 50 km availability, it is necessary to build 4 new scrap yards.

When the accessibility is reduced to 40 km, we have determined a minimum number of scrap yards to 24 (showing in the previous section) and there is necessary to increase the number of scrapers in the existing network by 7 points. When considering the completion of the present network of collection points, it is necessary to build 6 new sites.

It does not make economic sense to build a dense network for small accessibility distances therefore the last accessibility distances was 30 km. The construction of a completely new network needs to be ensured by building up scrap yards in 39 new locations. In the case of the completion of an existing scrap yards network, 17 new need to be built.

Table 1. Summarization of results

		Strategy A (K=50 km)	Strategy B (K=40 km)	Strategy C (K=30 km)
Approach 1 (new network)	Scrap yards	17	24	39
Approach 2 (expansion of network)	Scrap yards	44	46	57
	New scrap yards	4	6	17

These results can support decision-making for the state in this area. As can be seen from the results, in the long run it would be better to focus on creating a new network of scrap yards that will improve the quality of the system, e.g. reducing the number of scrap yards while providing better availability, which will also reduce the environmental impact. In the short term, it would be appropriate to complete a scrap yards network to achieve a better accessibility for inhabitants.

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