TRAFFIC ACCESIBILITY MODELLING OF THE MUNICIPALITIES IN THE CZECH REPUBLIC

MODELOVÁNÍ DOPRAVNÍ DOSTUPNOSTI OBCÍ ČESKÉ REPUBLIKY

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Abstract

For modelling and assessment of traffic accessibility and serviceability in the meaning of creation a coherent system a lot of methods is applied that use geoinformation systems such as e.g. analyses of results of Census of Population, Housholds and Flats (CPHF), network analyses, analyses of timetables, applications of gravity-operated models, traffic inquiries, field surveys, records of ticket sales etc.

Since 2006 VSB-TU Ostrava has prepared a database of traffic connections for needs of the Integrated information portal of the Ministry of Labour and Social Affairs (MoLSA) of the Czech republic and further activities of MoLSA and EO. Today the database involves records of traffic connections between individual municipalities of the Czech republic through the use of public transport for periods suitable for current commutation. Connections are chosen based on several criteria from the list of connections searched out by the Timetables application of the CHAPS spol. s.r.o. company. The database is used for searching job vacancies accessible by public transport from the place of residence on an information portal and also from agents at employment offices, the next utilization is e.g. in the area of assessment of investment projects in a department of labour market analyses.

Over the years the database was subject to many changes. Both in searching method and volume of data to be processed. A goal of this contribution is to do a brief summarization of the database development over the years, its utilization in modelling traffic accessibility as well as future prospects.

Abstrakt

Pro modelování a hodnocení dopravní dostupnosti a obslužnosti, ve smyslu tvorby uceleného systému, se používá mnoho metod využívající geografické informační systémy, jako např. analýzy výsledků ze Sčítání lidu, domu a bytů (SLDB), síťové analýzy, analýzy jízdních řádů, aplikace gravitačních modelů, dopravní ankety, terénní průzkumy, evidence prodeje jízdenek atd..

Od roku 2006 připravuje VŠB-TU Ostrava databázi dopravních spojení pro potřeby Integrovaného informačního portálu Ministerstva práce a sociálních věcí (MPSV) ČR a další činnosti MPSV a Úřadů práce. Databáze v současnosti obsahuje záznamy o dopravních spojeních mezi jednotlivými obcemi ČR s využitím veřejné linkové dopravy na doby vhodné pro běžné dojíždění do zaměstnání. Spojení jsou vybrána na základě několika kritérií ze seznamu spojení vyhledaných Jízdními řády společnosti CHAPS spol. s.r.o.. Databáze je využita k vyhledávání volných míst dostupných veřejnou dopravou z místa bydliště na informačním portálu i u zprostředkovatelů na úřadech práce, další využití je pro oddělení analýz trhu práce např. při posuzování investičních záměrů.

V průběhu let dostála tato databáze mnoha změn. Jak při způsobu vyhledávání tak pro objem dat pro zpracování. Tento příspěvek si klade za cíl udělat krátkou sumarizaci vývoje této databáze v průběhu let, její použití při modelování dopravní dostupnosti a rovněž výhledy do budoucna.

Key words: traffic accessibility, database of connections, public transport

1 INTRODUCTION

For most of citizens public transport is an indispensable public service ensuring traffic service in the territory and so accessibility of its destinations. The traffic system within the entire European Union reveals itself by an imbalance in division of transport labour. The users of the traffic system prefer individual automobile transport to financially and ecologically more favourable public mass transport. Specific aliquot parts of course

varies depending locality or kind of journey. However, in general one can say that public transport upon conditions of the Czech Republic has so far relatively advantageous position. It is proven even by a relative ratio of public transport[1] (PT) that decreases from year to year. In the year 2005 the ratio of public transport to the number of transported persons was 57.2% 0, in the year 2006 56,6% 0 and in the year 2007 56,0% [3], when a significant part is created by city transport.

The existence and parameters of PT connections affect the situation in the labour market. Although apparently less than one generally presumes [6]. When making decision on acceptance of a vacancy offer the question of traffic connections and associated costs of commutation play an indispensable role.

CPHF in the year 2001 [4] showed that 91 % of employed persons travel to work outside their place of residence. When going to work about 58% of employed persons move within the municipality of their domicile, remaining ones move out. Prague and the Central Bohemian Region are exceptions. When going to work in Prague 94 % of the whole stay in the city, on the contrary in the Central Bohemian Region only 39 % do not leave the municipality where they live. This finding confirms the idea of the function of this region for its inhabitants. This region fulfills largely a housing function only and a job function for its inhabitants is fulfilled by Prague [5] . For commutation only 5 % of employed people do not utilize any means of transport, thus remaining 95 % utilize some means of transport and thereof 75 % of the whole utilize only one means of transport. [4]

The first research of commutation was performed in Germany already in the 20th century. However, only in the last several decennia the issues are paid more attention. Nevertheless a very extensive literature exist dealing with questions of population commutation according to [11] . For example [13] evaluates the PT serviceability of provincial areas, [14] compares traffic accessibility of Prague from individual centres of municipalities with an extended competence through the use of individual transport and PT. [15] created a model of temporal accessibility using individual automobile transport. In Slovakia then [12], [16] and further publish.

Also J. Horák and his collective at VSB-TU Ostrava deal with the traffic accessibility analysis. Within the grant project "Spatial Analysis of Unemployment",GA 402/99/0022, and "Labour Market Modelling Using Geoinformation Technologies", 402/02/0855 (see http://gis.vsb.cz/PAN/) an assessment of the traffic accessibility and municipality serviceability was performed in the district of Bruntal with the highest rate of unemployment in the Czech republic. At that time tracking of accessibility of municipalities with notable employers was performed as for both PT and individual automobile transport. For searching connections in the programme Timetables of the CHAPS spol. s.r.o. company the application DOK has been created having been developed at the Institute of Geoinformatics in cooperation with the Department of Control Systems and Instrumentation since the year 2001.

Accessibility was modelled for travelling from the place of residence for 06:00, 07:00 and 08:00 and back to the place of residence for morning shift. Gradually commutation was modelled also for afternoon and night shifts. Among others real possibilities of commutation were assessed in relation to the price of labour including costs associated with commutation. Connections searched from the timetables analysis were recalculated using the information on fare reductions per month according to the scheduled tariff in the year 2004. Professions of job applicants in a chosen area were assigned by probable amounts of monthly wages, gross earnings were with the aid of 2 variants (self-breadwinner and a member of family of three with a partner paid at a medium and a child below 6 years of age) recalculated to relevant net monthly incomes. These professions were further classified in term of commutation to selected locations. It was proved a limiting factor is especially the amount of remuneration for work and commutation conditions (predominantly existence of suitable connection) than costs of commutation. [7]

2 PROGRAMME FOR SEARCHING TRANSPORT CONNECTIONS

The first version of the DOK application was performed in Visual Basic, ver. 5 within a diploma thesis by the student Eng. Tomas Kettner [20] . Later it was adapted for needs of other diploma thesis by the student Eng. Lukas Ruzicka [21] . Unfortunately the utilization of both versions was heavy-handed and non-intuitive. A subject matter of a separate chapter was to link the application to a new version of the timetables database of the IDOS application. For this reason we proceeded to redesigning with emphasis on easy and intuitive control, configurability, higher reliability and possible extension of the application by new functions. Realization of the new version was ensured by Eng. David Fojtik, Ph.D. from the Department of Control Systems and Instrumentation. The first version has been used also by students of other universities for their diploma theses. Of course, as mentioned above, because it was necessary to adapt directly the source code, the DOK programme was difficult to use for an ordinary user.

In the year 2006 a brand new version of the NEWDOK application occurred created in Visual Basic, ver. 6.0 with a new user interface and with a remade core increasing reliability and speed of the application. The NEWDOK application itself does not realize the search of connections directly, but via the product IDOS for

[1] Public transport involves railway transport, bus transport and city mass transport .

Windows. This product of the firm CHAPS spol. s.r.o. provides for payment applicable timetables of public transport. NEWDOK controlled the programme by a mechanism of message sending, thus by an imaginary keyboard simulation. It simply completed all criteria of the searched connection and requested its searching. IDOS searched out the connections and after a command entered them into a text file, from where NEWDOK read it and processed. A major problem of the presented solution consisted in the speed of data processing and potential instability. A reason was the way of communication with the IDOS application (message sending, file writing and reading) that is not only markedly slow, but also very sensitive to any user intervention. At the same time the application was used for a nationwide analysis of traffic serviceability, when numbers of found connections exceeded fifteen million of records. This extensive task was, of course, solved in a distributive way, by simultaneous processing of partial parts on as many as possible computers (tens computers concerned). Nevertheless, the own search of connections lasted several weeks.

For these reasons a new solution was searched that should make possible to search connections directly without a complicated and slow communication with the IDOS programme. Under an agreement with the CHAPS spol. s.r.o. company a licence has been purchased for the direct utilization of dynamically linked TT.DLL library for needs of processing the traffic connections database for MoLSA of the Czech republic. The new application called TRAM was prepared that uses the direct communication with the TT.DLL library and for the users a proved user interface, so there was no need to change the methodology of preparation and subsequent data processing [8]. The new method [9] is built on the client-server technology, where the server part is created by the MS SQL Server 2005 Database. The database involves all searched combinations of municipalities and also saves all found connections. The client part is formed by a set of computers with a special developed software performing the search of connections. The client commences the distribution of requests by sending a request for data. The server responses to the request by sending a group of requests. Then the connection between the client and server is interrupted, hereat the client starts searching the connections. As soon as the search is finished, the client establishes again the connection with the server and sends the found data en bloc and makes a request for another data group. Thereby a new searching cycle is commenced.

The client physically requests for data through a saved procedure of the server. This procedure will separate a new group from the so far non-processed requests (1200 records by default) and send it, and at the same time it makes a note what data, to whom and when was sent. Upon result receipt it identifies the data as having been executed. So the server permanently knows what requests, to whom and when have been sent, and possibly by whom processed. The information is important provided that some of the clients collapses during the data processing. The server recognizes the situation so that it did not receive any answer for the appropriate group within 30 minutes from sending (ca quintuple of average time of processing of a group).

The client software has been programmed on the NET platform in the language MS Visual Basic 2008. As mentioned above, the client will disconnect from the server after acquiring the data, and so save the server's system sources. In the disconnected state it performs searching connections and after processing the package re-establishes the connection with the server for handover of the found connections. So the capabilities of the NET platform are fully utilized. For searching connections the licensed library of the firm CHAPS is used. The client application accesses through the library to the applicable timetables, searches connections, calculates fare and the like. Based on new requests, details of individual connections are stored for each found connection. To save the data the format XML has been selected. Thanks to the new XML data type in SQL Server 2005 the details of connections are stored directly in the connection record. A more detailed description of the processing is given in [9] . As regards an applicability of TRAM, it may not be used for other purposes than for needs of MoLSA by reason of license conditions, thus in practice the programme is not used.

3 DATABASE OF TRANSPORT CONNECTIONS

In the first year of solution searching was performed for one-way connection from all municipalities of the Czech Republic to 70 km distant municipalities. It concerned overall 7 million combinations of municipalities for one shift, in total 21 million for morning, afternoon and night shifts. A year later searching was extended to the 100 km distant municipalities for the reason that between municipalities distant like that a good transport connection may exist using railway transport. In the last year using the TRAM application two-way processing of transport connections was performed that were searched in the interval from 04:00 a.m. - 12:00 p.m.

From the data found in this way a selection was performed restricted to the connections fulfilling the conditions as follows:

- Travelling time may not exceed 90 minutes
- Departure from the place of employment ideally 15 minutes after ending a shift and as fast as possible arrival from the place of employment home.

In the event of more suitable connections, it was necessary to decide on the best variant of connections that was used for determination of the required parameters; otherwise the saved data would be inconsistent, because the individual attributes would respond to different connections (thus e.g. the travelling time for 6.00 a.m. would be determined for other connection than its price) and this could lead to wrong interpretations. The

variant selection was performed according to the minimum distance excluding cases, when the variant showed significantly worse results in further indicators; then another optimum variant was selected. A more detailed description of the method is mentioned in [10].

When passing to two-way tracking of accessibility the method of selecting an optimum connection was modified. Today such connection with the highest value of the connection assessment criterion is considered as optimum. The assessment is based on the weighted arithmetic mean of assessment of the following parameters:

- Travelling time,
- Number of interchanges,
- Price,
- Distance,
- Time of departure,
- Time of arrival.

The individual parameters are assessed against the best possible result herewith that for some factors little differences from the optimum are permitted (e.g. a small difference in price, distance, travelling time). The times of departure and arrival are evaluated through the use of polynomial functions that allow to set an non-linear course of weights for taking into account an emphasis on the as late as possible departure to the place of employment, as soon as possible arrival from the place of employment and suitable (ideally 15 minutes before the shift beginning, or 15 minutes after the shift ending) arrival to the place of employment, or departure from the place of employment. The performed comparison of this selection with the expert selection shows ca 75 % success, i.e. approximately 3/4 of the selected connections are evaluated as optimum also according to the expert. It is necessary to accentuate that the assessment of the connection optimality is not and cannot be unambiguous, because it results from an subjective setting of selection priorities.

4 TRAFFIC ACCESSIBILITY MODELLING IN CR

Utilization of similar databases of transport connections is very wide, from local applications intended for research of accessibility of a potential investment and determination of its catchment area, up to republic basis, when it allows to model the situation transparently throughout the territory and look for differences in accessibility.

During the traffic accessibility modelling for the first time using the connection database an existence of certain transit corridors revealed itself that not always correspond to significance of road and railway networks. As well an interim regional comparison for the years 2006 and 2007 showed locations with dramatic changes, where especially the area of Northern Bohemia has lost significantly its traffic serviceability, which relates to a long-standing carrier strike at that time.

The comparison of traffic accessibility in the years 2006 and 2007 showed a considerable collapse of traffic accessibility for municipalities. A decline was watched in many regions of the republic except for Zlin Region; a powerful growth was indicated in the area of North-West Bohemia, where the reorganization of regional traffic services in the year 2006 has a negative influence to the situation in traffic. In a more detailed viewpoint, areas of two regions were analyzed and compared, when from the connections database and free accessible data the following fundamental indicators of the traffic serviceability were tracked: Number of transport connections for commutation for all monitored times in specified areas, average number of found transport connections in individual municipalities and number of interchanges. Here we focused on the analysis, to what extent the municipalities are: divided to size categories according to the number of inhabitants and serviced using the indicator *average number of connections* from the followed up municipalities. It follows from the results that in the investigated areas the municipalities in the segment up to 500 inhabitants and from 500 up to 5 thousand inhabitants are serviced the least.

The analysis tracking the municipalities with the similar development in the period of June 2007 - March 2008 compared the number of accessible municipalities for the times of morning, afternoon and night shifts from each municipality of the Czech Republic and further the number of connections outgoing from the municipality also for that times (Fig.1). The clustering method, more precisely the k-means algorithm [22] was used for formation of typologically identical areas. A cluster here means an arithmetic mean and 3 resulting groups (cluster centroids), to which the individual municipalities were consequently allocated in individual reallocation iterations. Minimization of the sum of the squares of the distances between objects in the cluster and the centroids were the optimality criteria. The results showed that in the first cluster no significant changes occurred namely for 5076 municipalities. In the second cluster a decrease of the number of accessible municipalities appeared namely in 859 municipalities. The most affected areas are municipalities in Pilsen, Jihlava, Hradec Kralove, Pardubice and Novy Jicin regions. So it does not concern a local situation at one site. A different situation is as concerns the last cluster that is created by municipalities with an increase of the number of accessible municipalities and that is represented by 312 municipalities predominantly of the Usti nad Labem Region. The change was most likely caused by re-entry to a needful level of the traffic serviceability after the

collapse in the year 2007. The situation was stabilized by subsequent utilization of an increased number of iterations. A more detailed description of the method is given in [17].

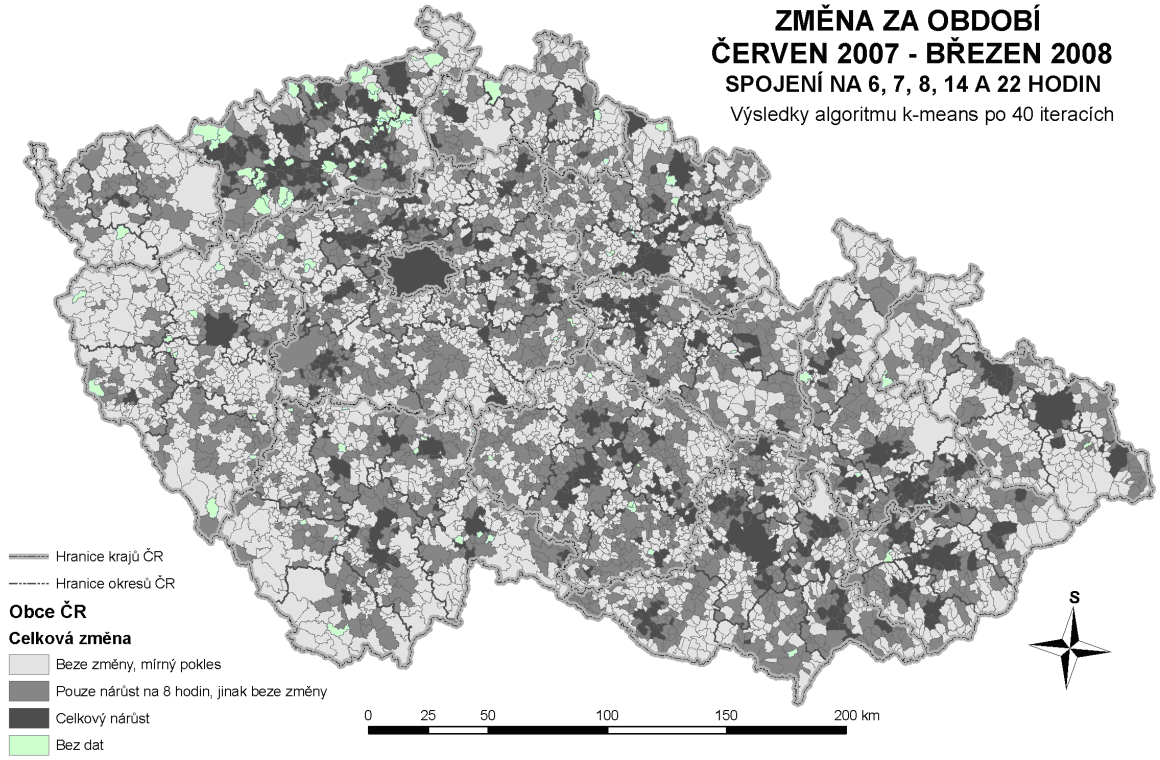
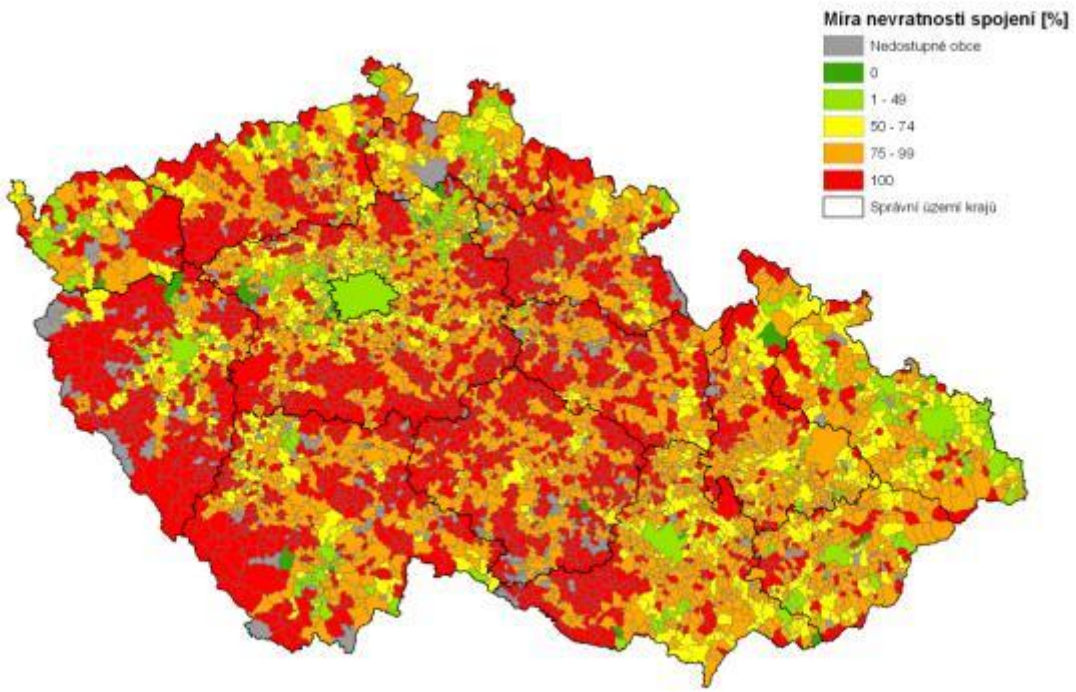


Fig. 1 Global change of connections from municipalities of CR using PT

Since most of analyses of commutation involves the situation of one-way commutation only, at the same time it is known that real possibilities of the return can disable the commutation or substantially weaken the interest of persons to travel to a given place, we tried to quantify the significance of this effect as well as to map also the spatial distribution of the effect. For assessment a method has been designed (described in a more detail in [9]) for computing the extent of decrease of accessible municipalities, or let us say the extent of non-reversibility of connections for individual monitored commutation times as well as the assessment of the weighted mean centre for all times analyzed by commutation.

The changes compared to the one-way tracking of commutation are substantial, as showed from the results. To analyze the rate of non-reversibility of connections three target times have been chosen. The mean values in these times differed from each other to a great extent. The largest reductions of accessible municipalities by reason of not existence of a suitable return connection (according to the introduced conditions), is in commutation for afternoon shifts, as they finish at 10 o'clock p.m., when the traffic serviceability especially of peripheral and rural areas is very low (Fig.2). On the contrary the least problems with the return from the place of employment are after ending of night shifts, when for the return journey connections from the starting morning peak can be used. However, as for night shifts there is a problem rather with the journey to the place of employment, where 40% of municipalities is inaccessible by PT (according to the introduced conditions). In commutation related to a morning shift of course a decrease exists with the number of accessible municipalities in the light of non-existence of a suitable return connection, however, the one does not achieve so staggering values, it ms about 36%.



Rate of connection non-returnability
Non-accessible municipalities
Administration area of regions

Fig. 2 Rate of non-returnability of connections in municipalities of CR to 2.00 p.m. valid for roadways 2007/2008 updated as of June 30, 2008

In interregional comparison a poor situation is obvious as for return connections in all studied hours in the Vysocina Region, namely at the borders with surrounding regions. It is followed by the Pardubice Region. The problems just at the borders between regions can be related to financing and ensuring the traffic serviceability by the appropriate regions, placing orders to carriers etc. The lowest rate of non-returnability of connections is recorded in Prague, but when excluding the specific region from the comparison, the best results are achieved by the Karlovy Vary Region, where probably a minor number of globally accessible municipalities can reveal itself (Tab.1), followed by the Moravian-Silesian Region. It can be said that the accessibility of municipalities when travelling to the place of employment and also when returning home is better in Moravia and Silesia than in Bohemia.

Tab. 1 Absolute numbers of accessible municipalities by PT in regions of CR

Region	Number of municipalities accessible					
	6 a.m. one way	6 a.m. return way	2 p.m. one way	2 p.m. return way	10 p.m. one way	10 p.m. return way
Prague Capital	565	535	500	294	301	286
Central Bohemian Region	60341	34696	49924	9407	15805	12847
South Bohemian Region	27467	15003	16528	2499	2812	2283
Pilsen Region	15571	8302	8783	1132	2171	1714
Karlovy Vary Region	**2984**	**2412**	**2931**	**752**	**815**	**738**
Usti nad Labem Region	13946	9443	13329	1713	3723	3239
Liberec Region	7044	4625	5777	1184	1832	1410
Hradec Kralove Region	24823	14152	14806	1229	3007	2580
Pardubice Region	28862	13040	15865	1236	1744	1427
Vysocina Region	46327	21079	25383	1171	2237	1778
South-Moravian Region	54159	35877	42560	6033	11114	9450

Olomouc Region	22610	13830	18428	2828	5110	4136
Zlin Region	20668	13458	16443	2555	5304	4356
Moravian-Silesian Region	14201	10250	12815	4295	6554	5437

For analyzing the commutation using the results of the connection database at the Geoinformatics Institute also door-to-door approach is applied for the total time and distance in the Moravian-Silesian Region [19] . It is possible to find a number of houses locating in a significant distance from the closest station of public transport and where walking time and distance can substantially affect the results. One works here with a calculation of service areas of stations and so-called active stations. These areas are described by an exploratory analysis and in a cartographic way [18]. At the same time a correlation is studied between the residence population size and the number of stations in its territory. A detailed description is devoted also to the quantification of the door-to-door approach effect, regions are calculated in certain distances from the PT stations on road and street networks and weighted mean walking time during commutation is specified.

The connection database now involves connections at the level of municipalities, of course much more detailed view at the level of parts of municipalities shows even dissimilarities within the area of a municipality, when some parts can be in the traffic network farther-out without any bus or train stations.

For visualization of the map outputs the programme product ESRI ArcGIS verze 9.x has been used.

The data from the traffic connections database was used, except for needs of the Information Portal of MoLSA CR, for an analysis of the traffic accessibility of the glass works in Svetla nad Sazavou that in the year 2008 faced to an economic crisis. The analysis has been performed for the local employment office.

5 CONCLUSION

The traffic accessibility has been studying at the Geoinformation Institute for years and the studies still continue. With the development of the software applied to searching PT connections also the area of interest was extended from the initial area of Bruntal across the entire republic. Results of the work showed a lot of interesting. Interregional comparisons between single years identified the areas of considerable changes. For example a decline of the traffic accessibility, or let us say serviceability in the Usti nad Labem Region after the reorganization of regional traffic services in the year 2007 followed by the situation improvement in the year 2008. In individual years the traffic situation did not significantly change in relation to the tracked times of arrival to the employment (6:00, 7:00, 8:00, 14:00, 16:00).

The study of the two-way commutation showed, how the absence of connection from the employment location to the place of residence can be a limiting factor for selection of a potential employment. It can be said that the accessibility of municipalities when travelling to the place of employment and also when returning home is better in Moravia and Silesia than in Bohemia.

At present possibilities of an extension of the connection database by searching through the use of city transport (public traffic) are analyzed as well as searching up to the level of parts of municipalities.

The traffic connection database can be extended by searching using city transport, because now it is possible to search only within public line transport. Here, it will be necessary to solve, whether there is no need for a part of a municipality to identify more optimum stations (for city transport and PT) and therefore the adaptation to the methodology of searching.

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RESUMÉ

Studium dopravní dostupnosti, jak už ve vztahu dojížďky do zaměstnání nebo do jiných významných cílů cest, je, bylo a stále bude v popředí zájmu, jak státní správy, tak dopravců. Dopravní dostupnost je studována na VŠB-TU Ostrava, kde se dané problematice věnujeme skoro desetiletí.

Pro potřeby MPSV ČR připravujeme databázi dopravních spojení mezi jednotlivými obcemi ČR do vzdálenosti 100 kilometrů pomocí veřejné linkové dopravy (VLD), autobusové a vlakové. Tato databáze je využívána k vyhledání volných pracovních míst dostupných VLD z místa bydliště např. do zadané vzdálenosti či času pro zvolenou profesi.

Příspěvek se zaměřil na krátkou sumarizaci vývoje této databáze v průběhu let, její použití při modelování dopravní dostupnosti a rovněž výhledy do budoucna.

Výsledky práce ukázaly mnoho zajímavého. Mezikrajská srovnání mezi jednotlivými roky identifikovala oblasti značných změn. Například úpadek dopravní dostupnosti, resp. obslužnosti v Ústeckém kraji po reorganizaci regionálních dopravních služeb v roce 2007 a následný zlepšení situace v roce 2008. V jednotlivých letech se dopravní situace nijak výrazně neměnila ve vztahu ke sledovaným časům nástupu do zaměstnání (6:00, 7:00, 8:00, 14:00, 16:00).

Studium obousměrné dojížďky do zaměstnání ukázalo, jak může být neexistence spojení ze zaměstnání do místa bydliště limitujícím faktorem pro výběr potencionálního zaměstnání. Výsledky ukázaly, že jak dostupnost obcí při cestě do zaměstnání, tak i při návratu ze zaměstnání je lepší na Moravě a ve Slezsku než v Čechách.

Databáze spojení nyní obsahuje spojení na úroveň obcí, ovšem mnohem detailnější pohled na úroveň částí obcí ukáže i rozdílnosti v rámci území obce, kdy některé části mohou být v dopravní síti odlehlejší, bez autobusové či vlakové zastávky.

Databázi dopravních spojení rozšíříme o vyhledávání s využitím městské hromadné dopravy (MHD), jelikož nyní je vyhledávání možné pouze pro veřejnou linkovou dopravu autobusovou a vlakovou. Tady bude zapotřebí řešit, zda pro jednu část obce nebude zapotřebí identifikovat více optimálních zastávek (pro MHD a pro VLD) a tudíž i přizpůsobení metodice vyhledávání.