LOCALISATION OF INTERCHANGE NODES IN THE REGIONAL CITIES OF THE CZECH REPUBLIC

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Abstract

This paper deals with the issue of localization of interchange nodes between urban and regional public transport in 13 regional cities (centres of NUTS3) in the Czech Republic. New methodology based on the utilisation of the valid time tables was developed to locate these transport nodes. It does not describe the situation of current flows of passengers but the theoretical localisation of these nodes is studied based on the offer of public transport connections. Then the homogeneity of localised interchange nodes was analysed according to the time of traveling and it was proved that the central role of the key interchange nodes is often even stronger during the evening hours. The assessment of the accessibility of these interchange nodes is also an important part of this paper. The situation in particular cities varies based on the position of this city in the national transport hierarchy but also regional factors take a very important role.

Keywords: interchange node, urban transport, public transport, commuting.

INTRODUCTION

The Institute of Geoinformatics has developed the Database of Public Transport Connections which is used for creating public transport service areas since 2006. This database was used by the Ministry of Labour and Social Affairs in the Czech Republic in their Integrated Informational Portal and also for many other needs of this national institution. It was updated three times during the year based on the main updates of the time tables (March, June and December). The main goal of this database is defining the area of interest where unemployed people can search a job which is in the evidence of the labour offices (all employers had a duty to inform the competent labour office about a new vacancy until the end of 2011). The transport accessibility is often a limited factor for job seekers. The database was extended in 2008; new attributes such as the existence of return connection after the end of the shift were added (more in Fojtík, Horák, Ivan, 2009). The last version of the database contains data about connections among all municipalities within 100 kilometres (Euclidean distance); it means more than 12.5 million records; and also among all municipality districts within the same distance (more than 73 million records). Each municipality is for the purposes of the connection database development defined by a random public transport stop. This fact causes many problems mainly in case of larger cities, where a peripheral stop is often selected as the target destination for potential commuting but the journey to the city centre is not considered. However, this part of the commuting process can be significantly time consuming, often more than the first part of the journey. It is important to exclude this limitation and to make the results more realistic. This process could be modified by two possible approaches. All cities could be represented by one central public transport stop close to the population centre or in the city centre and all connections would be searched considering this stop as the destination of commuting. But this approach brings other limiting factors – first of all: which stop to select? It does not cover the whole city; some transport modes are excluded etc. The second approach does not work with one representative stop but with a set of representative stops. These stops play an important role for the change between regional and urban public transport system within the city. The main function of these transport nodes is the function of transport terminals where the flows of commuting people start or end; or they change one transport mode for another (Rodrigue, Comtois, Slack, 2006). The interchange nodes are especially developed in places of crossing or approaching of two or more public transport links or transport modes. The most important requirement for the interchange nodes from the providers' point of view is the maximisation of securing passengers' safety by using the flyover crossings of roads or railways and footpath. The most important requirement from the passengers' point of view is the time needed to pass the flyover crossings and the whole process of the transport vehicle change; they prefer short one-level transfer. It is important to minimize the distance connected with the change of a transport vehicle. It is not the goal of this paper to find a new possible better transport terminals or interchange nodes but to select the main interchange nodes (stops, stations) from current stops used for the change of transport mode from the regional to urban public transport. The above mentioned methodology was accepted and these interchange nodes will be used as the representative stops of larger cities for developing the database of public transport connections. This paper describes the methodology of localisation of interchange nodes in 13 regional (NUTS3) cities in the Czech Republic; time stability of localised interchange nodes is studied and results of transport accessibility between old and new methodology are compared.

METHODOLOGY OF INTECHANGE NODES LOCALISATION

It is important to note at the beginning of this chapter that we do not analyse the real commuting flows and do not work with real numbers of passengers but we use the transport connection proposed by the valid time tables. This methodology deals with searching of a public transport (hereafter PT) connection between defined places of origin and a destination (see Fig. 1). The place of origin is defined as one of ten selected surrounding municipalities within 100 kilometres (Euclidean distance) around each of 13 regional cities. There are two important factors of these municipalities. Stable commuting flows (to work and school) among these municipalities and regional city according to results from 1980, 1991 and 2001 censuses (Czech Statistical Office) must exist there. These municipalities must be in all directions from the regional city to include possible commuting flows from all directions. Randomly chosen urban transport stops (hereafter UTS) stand for a destination. The count of these stops differs from city to city. In case of Prague, each city part has its own randomly selected UTS, so finally 57 UTS were selected. One UTS per city district was selected in Brno and Ostrava too, but to increase the total number of selected UTS, a few more were randomly selected and finally 50 UTS in each city were used. In case of smaller regional cities, 1 % of all UTS within the city were selected with 10 as a minimum.

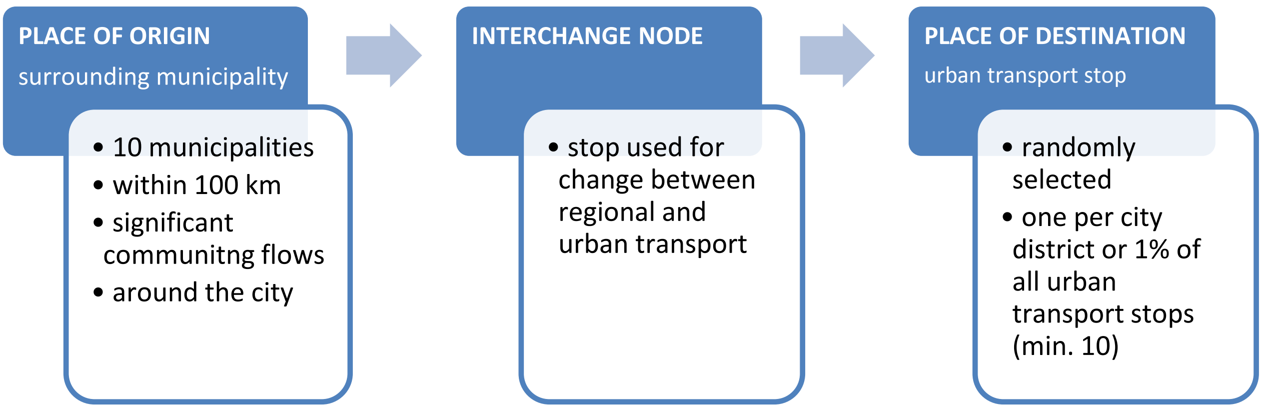

Fig. 1. The scheme of the used methodology

After the selection of places of origin and destination, valid transport connections have been searched using valid time tables with arrival at 8 a.m., 2 p.m. and 10 p.m. All connections have been searched for Tuesday, 22 June 2010 (Mudrych, 1998; Vonka et al., 2001). These connections must meet the criteria used for RPT connections in the Database of Public Transport Connections: total duration of commuting must be less than 90 minutes, the arrival to the final destination cannot be earlier than 60 minutes before the start of the shift and total number of interchanges must be less than 5 (Horák, Šeděnková, Ivan, 2008). The name and other attributes of a stop used for change between the regional and urban transport system have been saved for each best RPT connection. Overall more than 2.5 thousand of connections (for one commuting time) have been searched in time tables.

In case of Prague, Brno and Ostrava each RPT stop with the frequency of use above 10 is considered as interchange node. In case of other cities the selection of resulting interchange nodes was individual for each city. The total number of selected interchange nodes for 8 a.m. commuting is displayed in the table 1. Bus stops are used more often in case of all cities but when you compare the total number of particular interchanges or even the share of interchanges per stop, the situation will change and almost in all cities the majority of interchanges are made using railway transport. Cities can be more in detail divided according to the frequency of use of railway or bus transport stops. Olomouc, Ústí nad Labem, Brno and Prague are cities with the highest dependence on the railway transport considering the absolute number of interchanges per type of a transport. On the other hand, there are cities dependent on a bus transport – Jihlava, Karlovy Vary, Zlín and České Budějovice belong to this group. This situation is caused mainly by their peripheral position in the railway network hierarchy, out of the main railway corridors. The other possible aspect can be the number of interchanges per stop. The city most dependent on railway transport is Brno, where 55% of all interchanges are made using 33% of localised stops (railway stops) and the share of interchanges per one railway stop is almost 2.5 times higher in case of a bus transport. Brno is also interesting for the centrality of interchanges (similar to Hradec Králové), where the interchange nodes are used 2 times more often (more than 40 per stop) than in other cities (app. 20 per stop). The other cities with high centrality of interchanges using railway transport are Plzeň, Olomouc, Ústí nad Labem and Ostrava. To the contrary, Zlín and České Budějovice rely more on a bus transport.

Tab. 1. Number of selected interchange nodes in the NUTS3 cities (commuting to 8 a.m.)

NUTS3 Centre	Number of interchange stops			Number of intechanges			Interchanges per stop		
	Bus	Train	**Total**	Bus	Train	Total	Bus	Train	Total
Prague	6	8	14	131	179	310	21.8	22.4	22.1
Ostrava	10	3	13	177	108	285	17.7	36	21.9
Brno	6	3	9	167	205	372	27.8	68.3	41.3
Liberec	4	2	6	51	28	79	12.8	14	13.2
Pardubice	3	2	5	36	30	66	12	15	13.2
Plzeň	4	1	5	58	53	111	14.5	53	22.2
Ústí nad Labem	3	2	5	26	65	91	8.7	32.5	18.2
Jihlava	4	0	4	79	0	79	19.8	---	19.8
Karlovy Vary	3	1	4	54	13	67	18	13	16.8
Zlín	3	1	4	52	8	60	17.3	8	15
České Budějovice	2	1	3	49	11	60	24.5	11	20
Olomouc	2	1	3	15	43	58	7.5	43	19.3
Hradec Králové	1	1	2	43	37	80	43	37	40
Total	51	26	77	938	780	1,718	18.4	30	22.3

TIME STABILITY OF INTERCHANGE NODES

The above presented results describe the 8 a.m. commuting situation (commuting peak hour) but this can vary for different times. We localised these interchange nodes for the needs of commuting; that is why we analyse the situation also for other two times of arrival – 2 p.m. as the beginning of the second shift and for start of the night shift 10 p.m. We are focused on the spatial variability of interchange nodes; whether the interchange nodes and their frequency of use are stable or vary in case of 2 p.m. or 10 p.m. commuting. We studied this spatio-temporal stability of interchange nodes for three biggest cities (Prague, Brno, and Ostrava) and for Hradec Králové as the case of city with 2 equally used interchange nodes. The methodology used for this further analysis was the same as in the case of 8 a.m. commuting. In general, the number of significant interchange nodes decreased and the frequency of use of the most important nodes increased – principle of elitism. Another interesting aspect is a general decrease of existing connections fulfilling the conditions of presented methodology.

Based on 570 searched connections, 14 interchange nodes have been selected in Prague for 8 a.m. commuting. This number has decreased to 11 for 2 p.m. commuting and to 12 for 10 p.m. commuting. This development is quite unique among analyzed cities. The most important interchange node remains the railway station for all commuting times. In case of all analyzed times there is one bus stop with similar frequency of use as the most used node. Less important interchange nodes are often losing their role and the role of a few important interchange nodes is increasing for later time. The decrease is evident mainly in case of bus interchange nodes and increase in case of railway interchange nodes (increasing centrality of Masaryk Railway Station from 10% to 12% of all existing changes). Also the number of missing or unsatisfactory RPT connections is increasing from 15% to 25% for 10 p.m. commuting. The role of one interchange node in Prague is not as central as in case of Brno or Ostrava with share above 20% of all changes located in one stop. This is caused mainly by the large and heavily populated area of the city (almost four times bigger population than in Brno or Ostrava). Prague is a typical city with bigger number of interchange nodes with similar frequency of use without one or two significant central interchange nodes and with preferences of railway transport mode for commuting.

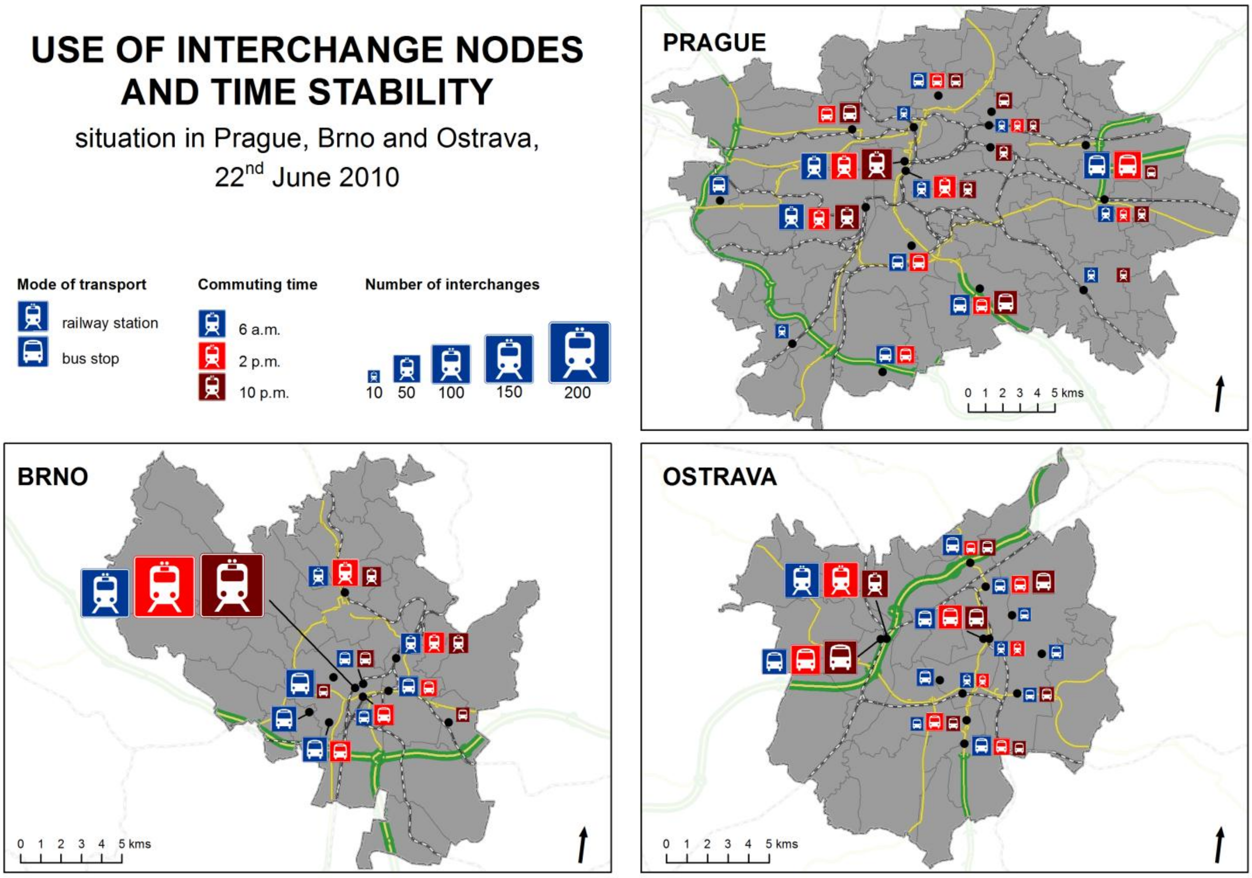

Fig. 2. Use of interchange nodes in Prague, Brno and Ostrava

The most important interchange nodes in Ostrava remain Railway Station Svinov and bus stop Svinov mosty; they service the connections from the western part of the Czech Republic. These two stops remain still the most important interchange nodes but they change their positions for the night shift commuting. In case of 8 a.m. commuting they are used for more than 25% of all interchanges and this share increases to one third of all interchanges for 10 p.m. commuting. The other important interchange node is the Central Bus Station in the city centre with increasing frequency of use from 6% to almost 10%. This stop serves the heavily populated eastern part of the region. Five sparsely used interchange nodes lost their position and were substituted by increasing frequency of use of main nodes in the city. However, the situation should change during next years because the city plan is to develop four main interchange nodes, this analysis locates two of these four planned nodes but only one belongs to the actual most important nodes (Svinov).

The most important interchange node in Brno for 8 a.m. commuting is Central Railway Station which has a frequency of use 31%. There is the lowest number of connections that were not available – these were not searched or they exceeded 90 minutes parameter. Nine interchange nodes were localized for 8 a.m. commuting, for 2 p.m. commuting six and finally, for 10 p.m. also six interchange nodes. Central Railway Station remains the most important interchange node for all three commuting times and frequency of its use increase from 31% up to 44,2% for 10 p.m. commuting. Central Railway Station remains the most important interchange node in all three commuting times and its role is rapidly increasing during the day which causes, similar to Ostrava, decrease of important interchange nodes – mainly bus stops. Mendlovo náměstí, Nemocnice Bohunice a Ústřední Hřbitov have altogether 25% frequency of use for 8 a.m. commuting and for 10 p.m. commuting only stop Mendlovo náměstí remains the interchange node with frequency of use of 3%.

COMPARISON OF ACCESSIBLE AREAS

This methodology has been used for the first time for three biggest cities in the Czech Republic – Prague, Brno and Ostrava. The Database of Public Transport Connections has extended almost 250 thousands of combinations (Ivan, 2011). Only 12% of these connections meet the criteria of the methodology of valid transport connection. Searching was carried out in program TRAM which is being developed at VŠB – Technical University of Ostrava; it works directly with the library of the time tables. (Fojtík, Horák, Ivan, 2009). This extension has proved the convenience of this approach and thus the application of this extension has been applied to other ten regional capitals.

Automated connection search among individual interchange stops and all municipalities within 100 km from Prague, Brno and Ostrava in both directions was carried out after the selection of interchange nodes. The search was carried out according to the same criteria as the connection search between the municipalities; time tables 2009/2010 updated to 14th June 2010 were used and 14th June 2010 was determined as a day of search. Results of the search were afterwards compared to the results of the connection search between municipalities in term of approachable area. Situation of commuting at 6 a.m., 7 a.m., 8 a.m., 2 p.m. or 10 p.m. was compared in both cases. Resulting situation in case of commuting to the cities (interchange nodes are considered to be final destinations) from municipalities within 100 km is displayed in the map below (picture 3). This direction of commuting is more frequent in the morning when people commute to the city to work or school. Above mentioned options, when as a final stop could be chosen any RPT stop and any stop in the city with the role of an interchange node, were studied. There is a significant difference between the number of municipalities when it is possible to use any final stop in the final destination and the number of municipalities when it is possible to use only any of the interchange nodes. It is caused by the fact that individual connections use as a final stop mostly these at the outskirts, so the connection does not reflect a long time that is needed to pass heavily urbanized areas in the cities on the way to city centre. In case of Prague, there is a significant decline in the number of municipalities from which is the city approachable. If it is possible to use any final stop in Prague, it is approachable from 1100 municipalities from surroundings. However, if it is possible to use only any of the interchange nodes, the number of municipalities drops to 302, it means more than 70%. It shows that previous results are not realistic in case of Prague. There is not such a significant decline in case of Brno and Ostrava (the number drops to 391 from 750 in case of Brno-almost 50% and in case of Ostrava it is 143 municipalities out of 252 which means 43% drop). Absolute numbers of municipalities cannot be compared due to different residential structure or closeness to the borders, however percentage declines are comparable.

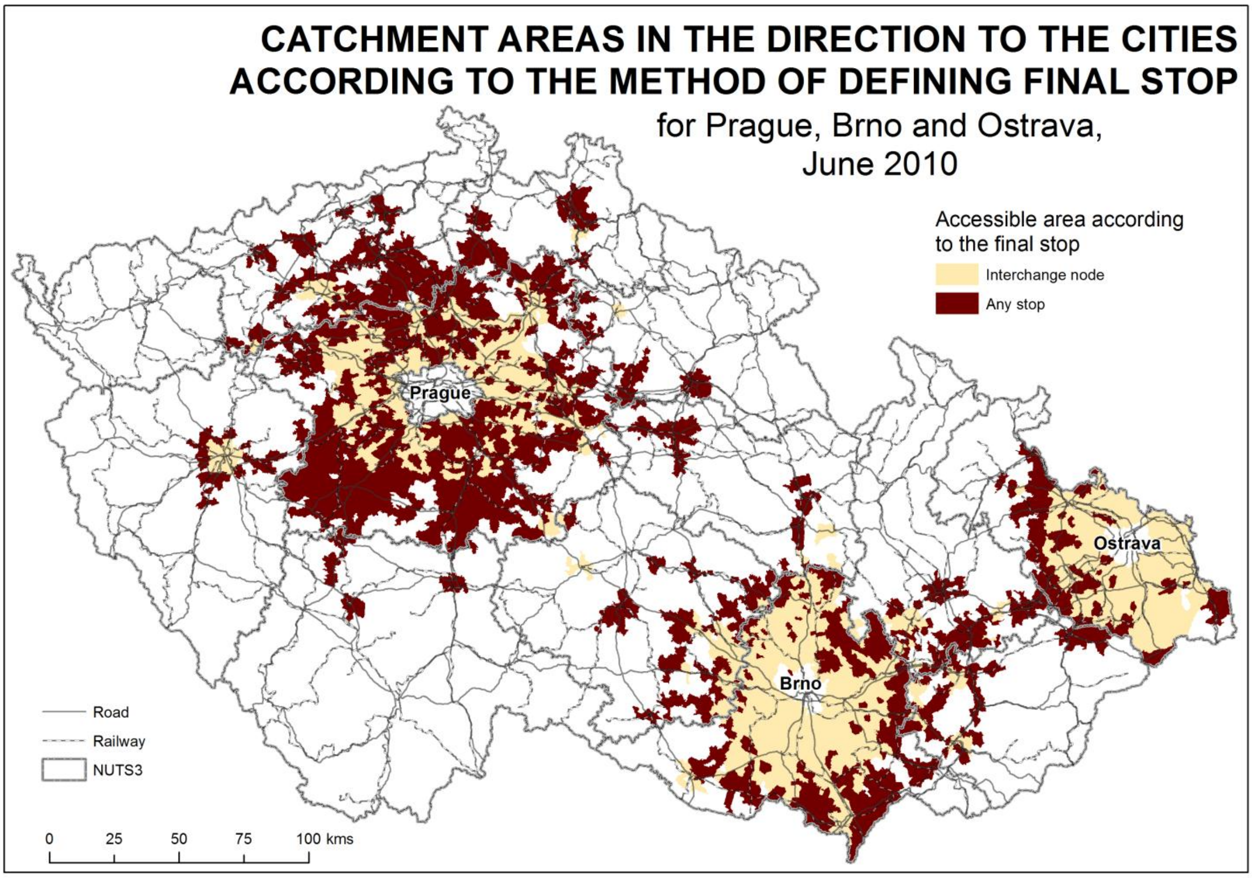

Fig. 3. Catchment areas in the direction to the cities according to the method of defining final stop

There are even more significant drops in case of analysing commuting to the other direction, i.e. from interchange nodes in the cities to surrounding municipalities in the radius of 100 km. This direction is used mainly in the afternoon to travel from work to the place of residence. The map (picture 4) shows differences; the most significant drops are again in case of Prague. If it is possible to use any RPT stop in Prague, 843 municipalities are approachable. However, if it is possible to use only any of the interchange nodes, the number of municipalities drops to 131. Decline is more significant than in the opposite directions and reaches almost 85%. From the map it is evident that even very close municipalities are not approachable from Prague. There is more significant drop in case of Brno too; mainly in the direction to the south and northeast from the city (the number drops to 255 from 647, it means 60% drop). The situation remained the same only in Ostrava where the number dropped from 216 to 119, 45% drop). It was caused mostly by more distant municipalities in Opava and Krnov region.

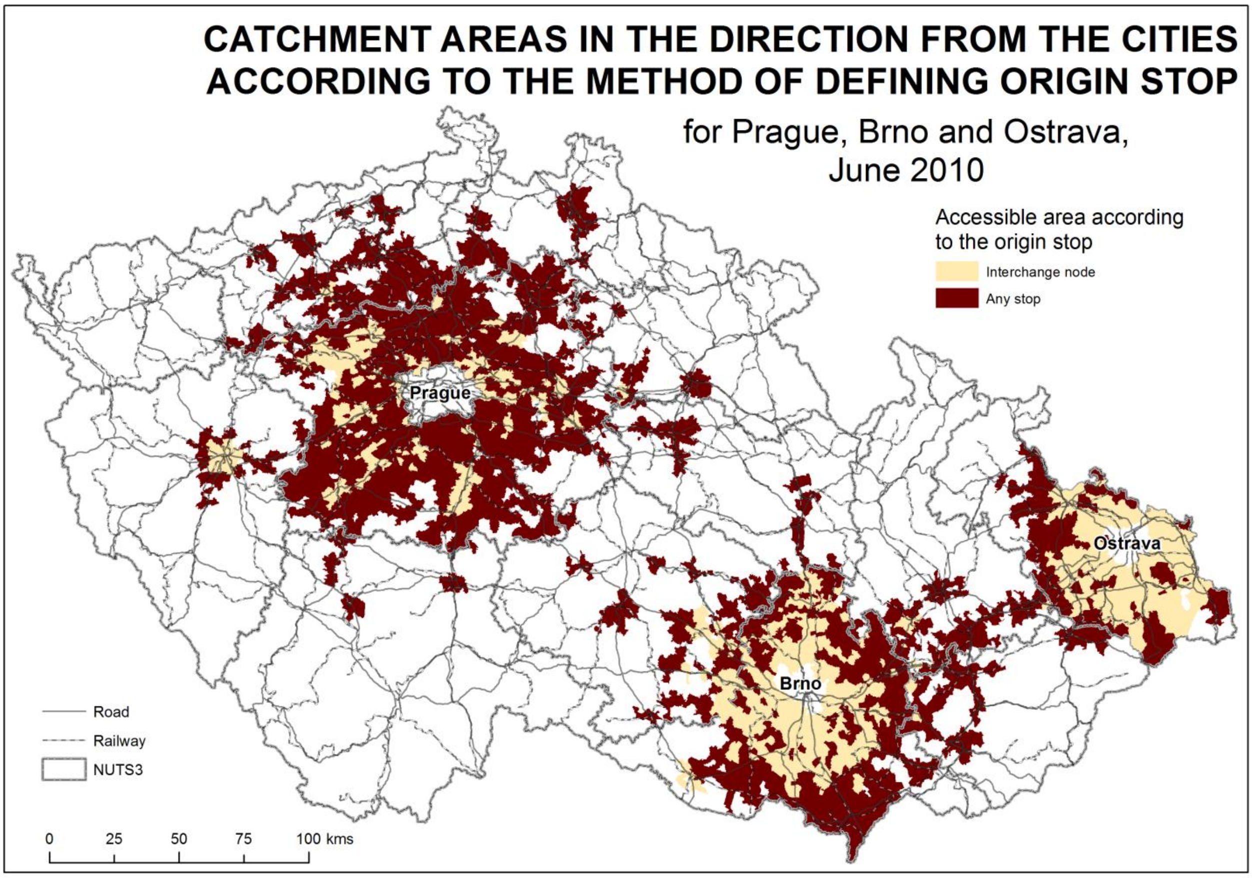

Fig. 4. Catchment areas in the direction from the cities according to the method of defining origin stop

CONCLUSION

The methodology for assessment of the interchange nodes within county capitals in the Czech Republic has been introduced. Based on this methodology; 77 interchange nodes for 8 a.m. commute have been localized. Generally, it is possible to divide cities into three categories according to dominance of train stop use or bus stop use for RPT change. In Prague there are more often used train stations (mostly Masaryk Train Station) and bus stops there often play secondary role. In case of Brno, there has been proved a key role of Central Train Station which is, in vast majority, used as a stop for RPT change. Also in Ostrava there is an important traffic node represented by train station Ostrava-Svinov and close bus stop Svinov, mosty dolní zastávka. In case of other regional cities the situation there is different, some cities rely completely on train stations (Olomouc, Ústí nad Labem etc.), some rely on bus transport (Jihlava, České Budějovice etc.) and some have similar use of both mode of transport (Pardubice, Hradec Králové etc.). Time stability of these interchange nodes for 2 p.m. and 10 p.m. commute have been investigated on the example of three cities (Prague, Brno and Ostrava). The results of the investigations tend to show similar figures. The number of significant interchange nodes has been falling and the frequency of use of some most significant interchange nodes has been rising. There has been a tendency to raise a number of connections which did not meet the criteria of method (commute time over 90 minutes or later arrival). New interchange nodes (less important due to their frequency of use) have appeared rarely.

These interchange nodes define these cities for the following automated connection search that has been performed for the combination of these three cities. The combination has been defined by any RPT stop or by any stop with the function of interchange node and by all municipalities within 100 km in airline from Prague, Brno and Ostrava. Due to comparison of number of approachable municipalities in the direction from and to the cities, the new methodology could be recommended to use. Number of approachable municipalities has fallen significantly - mainly in the surrounding of Prague by 85%. In case of Brno and Ostrava the drop has not been so significant; however, it has reached almost 50%.

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