Charles University in Prague
Faculty of Science
Department of Social Geography and Regional Development

Jakub Novák

MOBILE PHONE LOCATION DATA: POSSIBILITIES OF USE IN GEOGRAPHICAL RESEARCH

Synopsis of PhD Thesis

Prague 2010
Supervisor: Assoc. Prof. Zdeněk Čermák

INTRODUCTION

Spatial mobility of world population has been unbelievably changing during the last decades. People from poor countries are moving thousands of kilometers to developed countries with the vision of material prosperity. Airplanes transport thousands of people in hours to places, where people had travelled much longer recently. Similarly, also an ordinary weekday is for the majority of population connected with relatively long moves between different places of daily activities. Traveling between home, work, kindergartens and schools, shops and leisure activities takes the significant part of our daytime.

To capture the measureless amount of particular human creatures in their day-to-day moves through time and space seems to be almost impossible. In fact, it is not so unrealistic. Currently, we are surrounded by a number of electronic devices, which dispose with information about its location or record moving objects in their vicinity. Mobile phone is one of such devices. This dissertation is based on a simple idea of the use of information from mobile phones in geographical research to study spatial mobility of population. The practical verification of this idea is the main focus of the dissertation. This dissertation follows two main aims:

1. To introduce the possibilities of mobile phone location data to capture the spatial mobility of inhabitants. To discuss possibilities, limits and critical points of this new data source in research and practice.
2. To test mobile phone location data in two empirical case studies. To bring new evidence about spatial mobility and everyday life of inhabitants and to show the potential of mobile phone location data in sociogeographical research.

Table 1.1 introduces the basic skeleton of the dissertation and the partial aims of its particular chapters. The whole content of the dissertation is in annex 1.

Opening theoretical section of the dissertation discusses the concept of mobility and places spatial mobility within the context of its other forms and concepts (for ex. social, virtual) (chapter 2 of the dissertation). Methodical part discusses possibilities of capturing spatial mobility using the new communication technologies (chapter 3 of the dissertation). The main attention is paid to the possibilities of localization of mobile phones from the technical point of view as well as from the ethical and legislative perspective and to the usability of location data in academic research and practice.

Following two empirical case studies are focused on practical question of mobile phone data utilization in solving concrete research questions. The first empirical case study is concerned with evaluation of the spatial organization of the settlement systems

(chapter 4 of the dissertation). The commuting patterns and the ways how they form regional structures are studied on the example of Estonia. Information about day and night places of people´s ordinary stay are extracted from the passive mobile phone location data and used as empirical source for the case study. The second case study is dealing with the question of spatial mobility and activity patterns on individual level (chapter 5 of the dissertation). The attention is concentrated on a deeper understanding of the organization and the shape of daily patterns of activities and spatial movements. Spatial mobility of young people from Prague is analyzed using active localization of mobile phones. The recorded daily trajectories are complemented by direct interviews.

Table 1.1: Overview of basic structure, aims and content of dissertation.

Basic framework	Main aim	Content / topic
Theoretical	To fit spatial mobility into the general context of mobility, to discuss relation between spatial mobility and development of society.	Forms of mobility and mobility regimes. Daily mobility in time and space.
Methodical	To introduce the possibilities of the analyses of spatial mobility by mobile phone location data.	Mobile phone location data; Principles and accuracy of localization. Law and ethical questions; Usage in practice.
Empirical (case studies)	To show the potential of mobile phone location data in sociogeographical research. To bring new knowledge about spatial mobility and everyday life of inhabitants.	Spatial patterns of commuting flows, regionalization of daily moves of inhabitants in Estonia. Everyday life and mobility style of young urban professionals in Prague.

MOBILE PHONE AND LOCATION DATA

New electronic devices as a source of location data

New electronic devices offer a couple of advantages compared to traditional sources of information. The main advantage is the volume of digitalized location data and the lower financial and time demand of their gathering and processing. On the other side, a set of disadvantages is common for all types of new location devices:

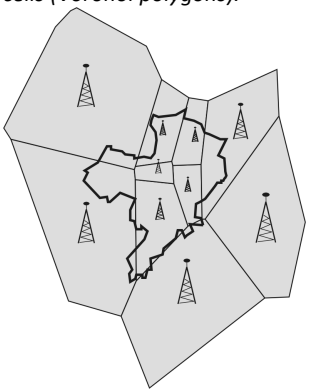
(1) location data are connected with the danger of privacy disturbance and human right restriction. The ethical and legal questions are not solved yet and also procedures of data processing are not stabilized;

(2) except of GPS location data, they often represent only the by-products of device functioning. Therefore they have a nontraditional form and a variable spatial accuracy (e.g. urban vs. rural environment);
(3) technical instruments how to deal with the new location data are not adequately developed;
(4) besides traditional methods the new devices record spatial mobility in partial ways, they gather only specific events or specific spatial behavior;
(5) the usage of new location data requires cooperation of academic sphere with private providers of mobile phone services, who do not have too much interest in it so far.

Localization of mobile phone

The signal of mobile phone is transmitted by a network of terrestrial antennas (*basic transmitter stations* BTS). The identification of basic transmitter stations (CGI – *Cell global identity*) represents the easiest and the simplest way of mobile phone location data gathering. From the geographical perspective the space could be divided into areas (cells), which are serviced by a particular antenna. Voronoi (Thiessen) polygons represent a simplified regional division of BTS cells (Ahas and Laineste, 2006; figure 3.3). Voronoi polygon of a particular BTS covers the area from where the nearest BTS is just this one (Boots 1986).

Figure 3.3: Outlines of approx. 15thousand Czech city with the borders of particular BTS cells (Voronoi polygons).



Source: Own figure.

A relative simplicity of information gathering through basic transmitter stations is counterbalanced by a lower spatial accuracy, which depends on the network architecture and the density of basic transmitter stations. BTS are covering large areas especially in sparsely populated places and therefore the location accuracy is low here.

The p location accuracy in the Czech Republic is ranging from 200 m in central parts of Prague to almost 6500 m in small villages in rural areas (table 3.4). The accuracy is gradually worsening in direction from the urban centre to the city outskirts. Similarly, a gradual decrease of spatial accuracy with the decrease of population size is notable in comparison of Prague with other cities and settlements.

Table 3.4: CGI location accuracy in the Czech Republic.

Area	Average distance between BTS (m)*	Average size of cell (km^2)**	Edge of square (km)***	Population density (inhab./km^2)
Prague - center	190	0,092	0,304	8 079
- inner city	386	0,479	0,692	4 109
- outer city	632	1,316	1,147	2 886
- outskirt	1 113	3,830	1,957	500
Prague -total	458	0,858	0,926	2 395
Regional centers	597	1,782	1,335	1 558
Hinterland of Prague and other regional centers	2 726	19,285	4,392	107
Big cities	1 163	12,176	3,489	643
Medium cities	2 895	33,553	5,793	237
Small cities	3 795	36,578	6,048	115
Villages	4 310	42,188	6,495	44
Czech Republic	2 324	21,144	4,598	139

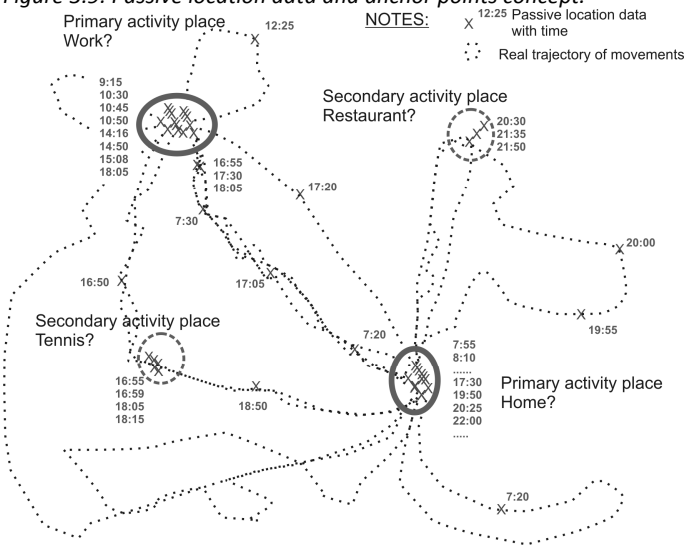
** Average distance to the nearest BTS.*
*** Average size of BTS cells covering area of municipality.*
**** Edge of square, which extent is same as average cell size.*
Source: Own calculation.

Types of location data

Two basic types of location data and specific methods of their gathering principally exist (Ahas and Laineste, 2006; Ahas et al., 2007a; Dufková et al., 2008). The first type represents the passive location data, where locations are extracted from the information on calls and sent SMS saved in billing data. The antennas´ statistics represent a specific kind of passive location data covering the aggregated information on the intensity of antennas´ use and its variation in time. Information from active tracking of mobile phones are the second type of location data. Active tracking is based on periodic questioning of mobile phone location done by a special software (figure 3.10).

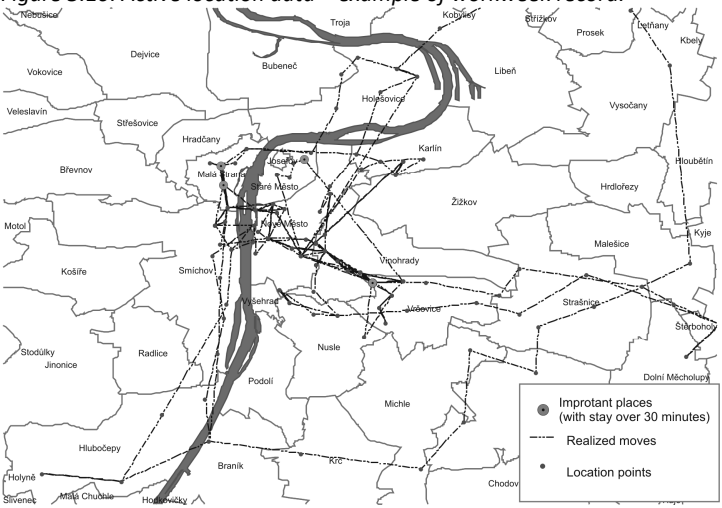
The concept of anchor points is the key analytical instrument for data mining to collect useful information from passive location data (figure 3.9). The anchor points are understood as the main locations of everyday human activities, which form a skeleton of daily moves (Golledge and Stimson, 1997). The algorithm of anchor point identification in passive location data is based on the evaluation of frequency and timing of location points in particular places (Nurmi and Koolwaaij, 2006; Laasonen 2009).

Figure 3.9: Passive location data and anchor points concept.



Source: Own picture.

Figure 3.10: Active location data – example of workweek record.



Source: Own research.

Potential usage

Miller (2004) considers mobile phone location data as the base for an entirely new methodology to study and understand human mobility in contemporary society. Ratti and col. (2006) talk about a new mobile landscape, which can be captured and analyzed with mobile phones. The potential areas of mobile phone location data usage in research, practice and commercial sphere are outlined in table 3.7. The advantages and disadvantages of mobile phone location data are briefly summarized in table 3.3.

Table 3.7: Possible use of mobile phone location data in research and practice.

Urban and regional analyses	Capturing of urban space dynamics, time-space characteristics of city functioning.
	Daily spatial mobility of inhabitants in urban and metropolitan regions.
	Alternative, complementary to commuting data from censuses.
	Present population in selected localities and its fluctuation during 24hours (week, year).
	Functional characteristics of particular localities, relation between urban form and function.
	Identification of week points in city infrastructure.
Transportation (urban, national level)	Monitoring of transportation flows between various parts of city (region, state) during 24 hours (week, year), O-D (origin-destination) models, real-time monitoring of actual traffic.
	Possibility of precise estimation of traffic loads on particular roads – alternative to traffic surveys.
Regional and spatial planning	Traffic engineering (project of new communications, metro lines and trams).
	Optimalization of public transport (public transport network, time schedules).
	Administrative division of states and regions, public service areas (accessibility of doctor, school...).
Tourism	Spatial mobility of tourists, duration of stay, visit rates, places of overnight stay.
	Information for formulation of regional strategies for improvements and development of tourism.
Location base services	Navigation, localization of persons, geographically filtered information, charging of entrance, social interactive services, public transports systems with actual position of vehicles and estimated times of arrival.

Source: Own overview.

Table 3.3: Advantages and disadvantages of mobile phone location data.

Advantages	**Disadvantages and limits**
+ Low price of location data; + Low time demand of data processing; + Time flexibility of research (duration of research, repetitiveness); + Size of population.	- New and not adequately tested method; - Not solved legal and ethic questions (security of personal information, anonymity provision); - Limited cooperation with private sector.

Source: Own overview.

4. REGIONAL PROCESS AND SPATIAL MOBILITY OF INHABITANTS IN ESTONIA

"Evaluation of the status and development tendencies of commuting patterns can be marked as the most important tool to study relational organization of sociogeographical systems and as a base for sociogeographical regionalization"

Hampl (2004, p. 210).

Theoretical bases

The theoretical background of the empirical study is based mainly on the theory of sociogeographical (functional) regions and the theory of development of spatial structures of settlements and regions (Hampl 1966; Brown and Holmes, 1971; Hampl 2005). Afterwards, current development tendencies of spatial structures and the mutual relations are discussed in detail (Garreau 1991; Clark and Kuijpers-Linde, 1994; Cervero and Wu, 1997; Anas et al., 1998; Dieleman and Faludi, 1998; van der Laan, 1998; Hampl 2005). The attention was paid also to the questions of definition and delimitation of functional regions (Brown and Holmes, 1971; Hampl et al., 1978; Coombes et al., 1986; van der Laan 1998; Casado-Díaz 2000; Nielsen and Hovgesen, 2005).

Main aim

1. **Delimitation of sociogeographical regions (regionalization)** with the utilization of mobile phone location data. The commuting to work and to schools is substituted by relations between the places of ordinary daytime and nighttime stay, which were identified in location data.
2. **Evaluation of basic characteristics of daily spatial behavior of population. The o**rdinary places of daytime and nighttime stay are used for the analyses of commuting.

Methods

The unique data source for the study was gathered by the company Positium and kindly afforded by the department of human geography at the University of Tartu, namely by prof. Rein Ahas. Passive location data recorded during January 2008 for 90 000 persons were used as a basic data set. The size of sample represents almost 6,7 % of population in Estonia. The identified nighttime and daytime anchor points were used for the construction of commuting flows.

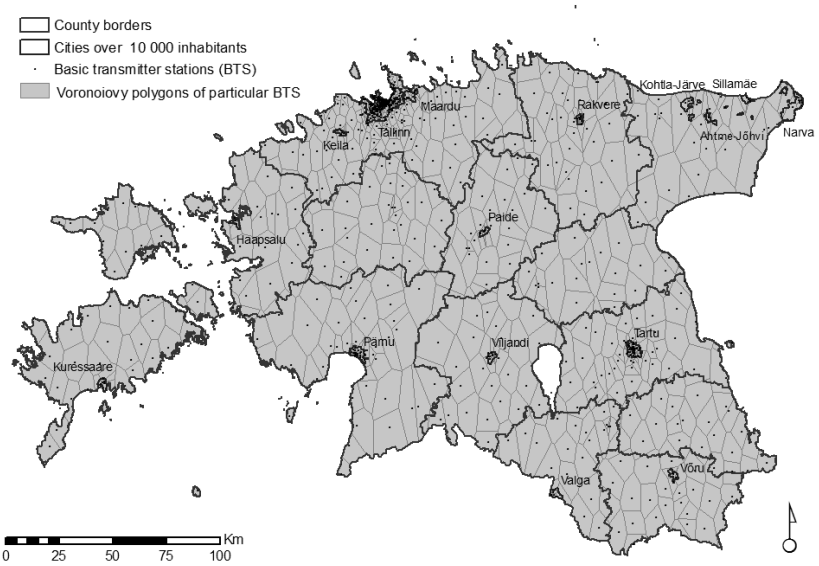
Main outcomes

- The construction of commuting flows (figure 4.8) from passive location data was allowed by a unique transformation of cell raster (figure 4.4) into network of

settlements (figure 4.7). The commuting flows were consequently used for regionalization of daily moves of population in Estonia.

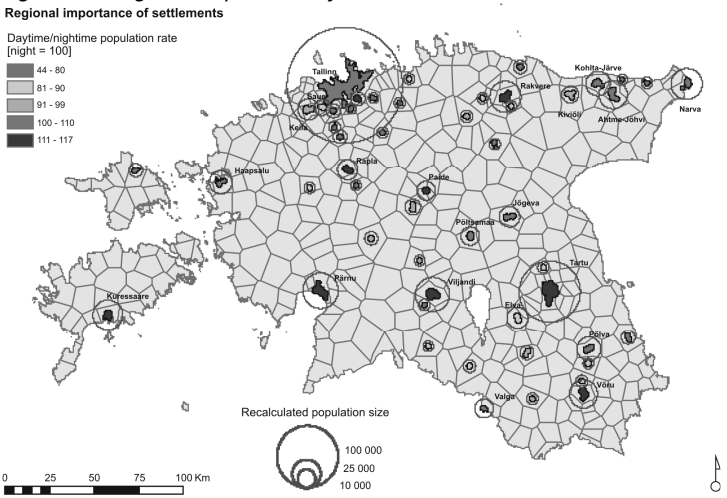
- The analyses of commuting flows and the regionalization of daily moves of population in Estonia confirm, that passive location data in combination with anchor points identification represent a suitable alternative for the surveys of daily spatial behavior of population.
- The analyses of commuting behavior at individual level notify: (1) marked differences in commuting rate and distance according to gender, (2) specific character of spatial mobility of young people in age group 20-24, (3) relation between decrease of settlement size and increasing commuting rates with marked division line among settlements bigger and smaller than 5000 inhabitants, which corresponds to the loss of central functions of settlements, (4) distinct spatial behavior of people living in hinterland of Tallinn.
- Regionalization of daily moves of population in Estonia is a big promise for th utilization of mobile phone location data in the study of settlement spatial organization, inner functional structures of metropolitan regions and transformation of mutual relations within settlement systems.

Figure 4.4: Distribution of BTS, Voronoi polygons and administrative borders in Estonia..



Source: Location data (2008).
Note: Borders of spatial units represent Voronoi polygons, which belong to particular BTS.

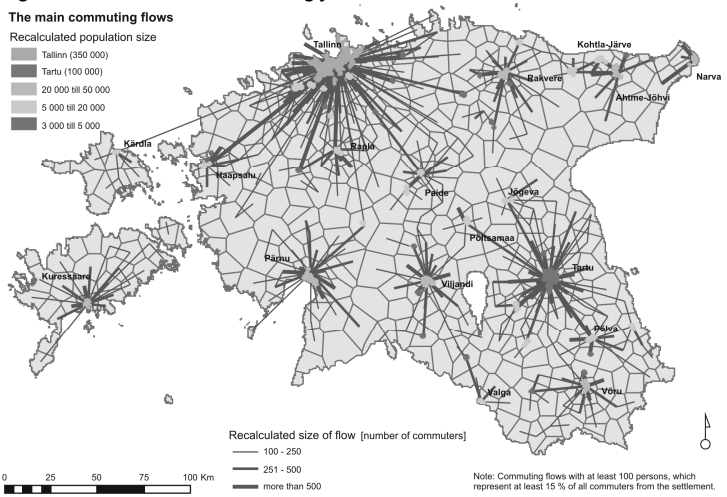
Figure 4.7: Regional importance of settlements.



Source: Location data (2008).

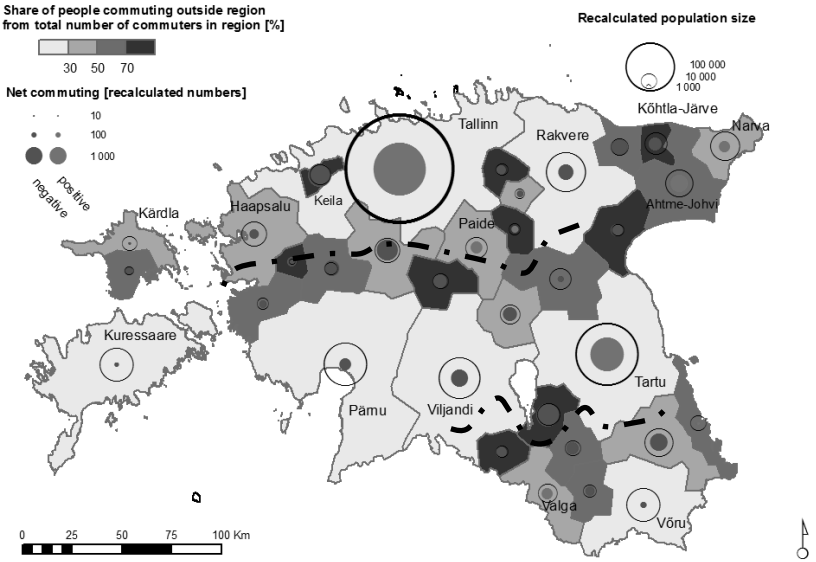
Note: Borders of spatial units represent Voronoi polygons, which belong to particular BTS.

Figure 4.8: The main commuting flows.



Source: Location data (2008).

Figure 4.9: Delimitation of microregions of the 1st level.



Source: Location data (2008).

5. EVERYDAY LIFE AND MOBILITY STYLE OF YOUNG PEOPLE IN PRAGUE

Theoretical input

In theoretical background the case study combines three theoretical sources. iHägerstrand's time geography is in the first place (Hägerstrand 1970; Thrifta 1977; Pred 1977; Parkes and Thrift, 1980; Pred 1981; Hägerstrand 1982; Halin 1991; Ellegård 1999; Ira 2001; Novák and Sýkora, 2007). The weaknesses in the explanation of the human decision making and the strategies of behavior in everyday life are often mentioned as deficiencies of time geography (Halin 1991). A set of studies, which can be summarized under a common working title "geography of everyday life", is concentrated just on this issue (Pratt 1996; Jarvis 2005) and serve as the second theoretical source. The last and important input is provided by the theoretical question connected with the relation between everyday life, daily spatial mobility and life style (Lanzendorf 2002; Scheiner and Kasper, 2003).

Hypothetical construction of everyday mobility style

The recorded trajectories of movements represent a particular form of personal time-space signature (Mateos 2005). The stations (visited places) and their chronological sequences are the most important elements of the signature. For the majority of people, everyday activities take a form of differently frequented routines of movements, realized activities and visited places. The interconnection of the skeleton of regularly repeated activities, visited places and ways of moving among them conditioned by individual motivations, decisions and strategies is forming a specific style of everyday mobility. Related to the concept of styles, Velký sociologický slovník (1996, p. 1245)mentions partial fragments of style called "style-forming aspects", which are used especially in the case of large behavioral complexes and complicated patterns of behavior. For the construction of everyday mobility styles we can think of these "style-forming aspects": (1) number of stations (uniquely visited places of daily activities), (2) spatial extent of daily moves, (3) routines and variability of spatial and activity patterns and finally (4) character of visited places and type of realized activities (workplace vs. free time activities). A particular style is defined as specific combination of the above mentioned "style-forming aspects".

The young and educated inhabitants and users of Prague represent a specific group of city population. The main aim of the study is to examine the hypotheses on the existence of various everyday mobility styles within this population group.

Methods

The whole research was realized in cooperation with Research and Development Centre for Mobile Applications (RDC) at ČVUT in Prague. A new software application SS7tracker developed by RDC was used for active localization of respondents' mobile phones (Dufková et al., 2008). Time-space trajectories of respondents were recorded from 29.9.2008 to 10.10.2008 (the example of movement trajectories during one week is presented in figure 3.10 in methodical section). Afterwards, the spatial trajectories were complemented by directed interviews for deeper understanding of individual strategies, barriers, decision making and subjective perceptions of respondents. The records of daily trajectories were acquired for 61 respondents and 47 of them were suitable for initial quantitative analyses. Finally, directed interviews were realized with 20 selected respondents. With the respect to a small sample the aim of study was not to provide representative picture of everyday life and mobility, but rather to introduce the idealized types of mobility styles and to deeper explore their nature.

Main outcomes

- A marked variability of relation between the number of visited stations and the total length of realized moves is visible in figure 5.6. It confirms the existence of

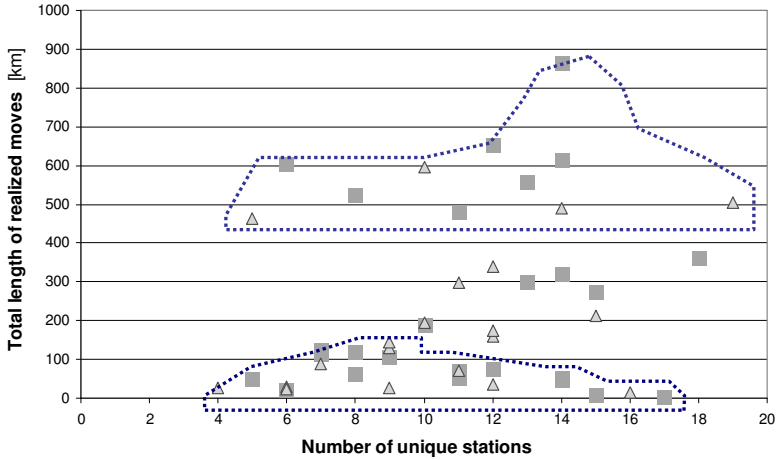
different styles of spatial mobility ranging from a large number of stations on a small space to a small number of stations on a large area.

- Approximately a half of respondents (51 %) did not overcome a distance longer than 150 km during a workweek (i.e. 30 km per day in average). On the other side, a group of hyper mobile respondents is markedly visible in figure 5.6. They travel more than 450 km in a workweek (i.e. 90 km per day in average) and represent 23 % of the respondents. There are no significant differences by age and gender among the respondents. The exception is the above mentioned group of hyper mobile people, which is dominated by men.
- Similarly, the daily activity space represented by the maximum distance of station (place of activity) from home is for the two thirds of respondents smaller than 13 km (figure 5.7).
- The main building blocks forming a style of everyday mobility are: (1) number of stations (uniquely visited locations), (2) extent of daily moves, (3) routines / variability of spatial patterns of activities and (4) localization of stations and a kind of realized activities. The number of stations and the variability / routines of activities were selected as the primary differentiation dimensions (figure 5.10).
- Four specific styles of daily mobility were identified: (1) **work driven active style**, (2) **free time driven active style**, (3) **routine dual regime connected with child care** (4) **routine dual regime connected with long distance commuting**.
- **Active style of daily mobility** is characterized by a high number of visited places and a variability of activities. Two categories can be distinguished according to the style forming aspects. In the first case, work and work related mobility is the source of the majority of activities **(work driven active style)**. In the second case, activities and stations are connected with free time after or before work **(free time driven active style)**. Daily mobility and activity regime of a young architect and designer is a typical example of work driven active style. His daily activities are not concentrated at one place and he realizes several work related trips during the day (e.g. work meetings, control days, exhibitions, purchase of material). An young independent manager living and working in the wider city centre is a typical example of free time driven active style (also a typical representative of young urban professional). Generally work is concentrated at one place in stable working hours, while the majority of other stations is connected with diverse activities realized in leisure time (sport, culture, education and meeting with friends).
- The routine style is typical by a small number of visited locations and a high share of routines of daily activities. The primary places of activities (home, work) play the dominant role in daily mobility and activity patterns of routine persons. Therefore the spatial mobility is highly influenced by spatial relation between the home and the work. A dual nature is an important aspect of routine style. Two types of days are changing – day at home and day at work. Two categories of routine style can be distinguished by the reasons of duality within days. A regular changing of

working days and days spent by child care is characteristic for the representatives of the first category **(routine dual regime connected with child care)**. In the second category duality is generated by long distance between home and work **(routine dual regime connected with long distance commuting)**.

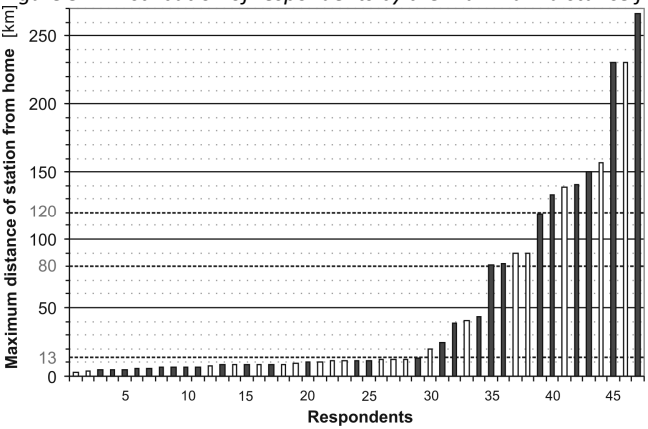
- The study pointed out the importance of other aspects of spatial mobility such as number of visited stations and routines of activities aside traditional dimensions of time-space behavior (length of moves, time use structure, extent of activity space).
- The empirical case study of everyday activities and mobility of young inhabitants in Prague demonstrate the methodical contribution of active location data of mobile phones in combination with directed interviews. Combination of longer term records of spatial movements (by active localization of mobile phones) with brief dairy notes and interpretative interviews seem to be a very promising research method. The positive responses from the respondents confirm the advantages of the method (low time burden for respondents and "enjoyableness").

Figure 5.6: Distribution of respondents by the number of unique stations and total length of realized moves.



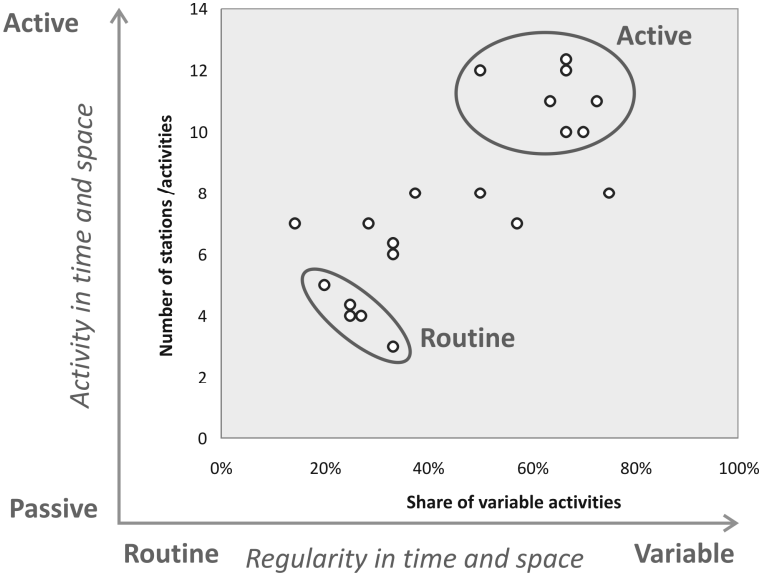
Note: Triangles show respondents selected for interview. Respondents who travelled less than 150 km, resp. 450 km per workweek, are marked by dot lines.
Source: Own survey. Number of respondent = 47.

Figure 5.7: Distribution of respondents by the maximum distance from home.



Note: Light color show respondents selected for interview.
Source: Own survey. Number of respondent = 47.

Figure 5.10: Distribution of respondents by the number of stations and routines of activities.



Source: Own survey. Number of respondent = 20.

SELECTED LITERATURE

Ahas, R., Laineste, J. (2006): Technical and methodological aspects of using mobile positioning in geographical studies. In: Pae, K., Ahas, R., Mark, Ü. (eds.), Joint space. Open source on mobile positioning and urban studies. Positium, Tallinn, s. 37-43.

Ahas, R., Aasa, A., Silm, S., Aunap, R., Kalle, H., Mark, Ü (2007a): Mobile positioning in space-time behavior studies: social positioning method experiments in Estonia. Cartography and Geographic Information Science 34(4): 259-273.

Anas, A., Arnott, R., Small, K.A. (1998): Urban spatial structure. Journal of Economic Literature 36(3): 1426-1464.

Boots, B.N. (1986): Voronoi (Thiessen) polygons. Concepts and techniques in modern geography (45), Geo Books, Norwich, UK.

Brown, L.A., Holmes, J. (1971): The delimitation of functional regions, nodal regions, and hierarchies by functional distance approaches. Journal of Regional Science 11(1): 57-71.

Casado-Díaz, J.M. (2000): Local labour market areas in Spain. A case study. Regional Studies 34(9): 843-856.

Cervero, R., Wu, K-L. (1997): Polycentrism, commuting, and residential location in the San Francisco Bay area. Environment and Planning A 29(5): 865–886.

Clark, W.A.V, Kuijpers-Linde, M. (1994): Commuting in restructuring urban regions. Urban Studies 31(3): 465-483.

Coombes, M.G., Green, A.E., Openshaw, S. (1986): An efficient algorithm to generate official statistical reporting areas: the case of the 1984 travel-to-work areas revision in Britain. The Journal of the Operational Research Society 37(10): 943-953.

Dieleman, F.M., Faludi, A. (1998): Polynucleated metropolitan regions in Northwest Europe: theme of the special issue. European Planning Studies 6(4): 365-377.

Dufková, K., Ficek, M., Kencl, L., Novák, J., Kouba, J., Gregor, I., Danihelka, J. (2008): Active GSM cell-id tracking: where did you disappear? In: MELT 2008: Proceedings of the First ACM International Workshop on Mobile Entity Localization and Tracking in GPS-less Environments, San Francisco, s. 7–12.

Garreau, J. (1991): Edge City: Life on the New Frontier. Doubleday, New York.

Golledge, R.G., Stimson, R.J. (1997): Spatial Behavior: A Geographical Perspective. The Giulford Press, New York.

Hägerstrand, T. (1970): What about people in regional science? Papers of the Regional Science Association 24: 7-21.

Hägerstrand, T. (1982): Diorama, path and project. Tijdschrift voor Economische en Sociale Geografie 73(6): 323-339.

Hallin, P. (1991): New paths for time-geography? Geografiska Annaler 73B (3):199-207.

Hampl, M. (1966): Příspěvek k teorii regionu. Sborník ČSSZ 71: 97-114.

Hampl, M. (2004): Současný vývoj geografické organizace a změny v dojížďce za prací a do škol v Česku. Geografie-Sborník ČGS 109(4): 205-222.

Hampl, M. (2005): Geografická organizace společnosti v České republice: Transformační procesy a jejich obecný kontext. Univerzita Karlova v Praze, Přírodovědecká fakulta, DemoArt, Praha.

Hampl, M., Ježek, J., Kühnl, K. (1978): Sociálně geografická regionalizace ČSR, Praha, VÚSEI.

Ira, V. (2001): Geografia času: prístup, základné koncepty a aplikácie. Geografický časopis 53(3): 231-248.

Jarvis, H. (2005): Moving to London time, household co-ordination and the infrastructure of everyday life. Time & Society 14(1): 134-154.
Laasonen, K. (2009): Mining Cell Tranition Data. PhD Thesis. Department of Computer Science, Series of Publications A, Report A-2009-3, Faculty of Science, University of Helsinki, Helsinki.
Lanzendorf, M. (2002): Mobility styles and travel behavior. An application of a lifestyle approach to leisure travel. Transportation Research Record 1807: 163-173.
Mateos, P. (2005): Mapping the Space of Flows: Evaluating Mobile Phone Location as a Method to Track the Mobile Society. CUPUM2005 Conference, London.
Miller, H.J. (2004). Activities in space and time. In: Stopher, P. Button, K., Haynes, K., Hensher, D. (eds.), Handbook of Transport 5: Transport Geography and Spatial Systems, Pergamon-Elsevier Science, Amsterdam, s. 647-660.
Nielsen, T.A.S, Hovgesen, H.H. (2005): Urban fields in the making: new evidence from a Danish context. Tijdschrift voor Economische en Sociale Geografie 96(5): 515-528.
Novák, J., Sýkora, L. (2007): A city in motion: time-space activity and mobility patterns of suburban inhabitants and structuration of spatial organization in Prague metropolitan area. Geografiska Annaler 89B (2): 147-168.
Nurmi, P., Koolwaaij, J. (2006): Identifying meaningful locations. 3rd Annual International Conference on Mobile and Ubiquitous Systems: Networks and Services (Mobiquitous). IEEEC Computer Society, San Jose.
Parkes, D., Thrift, N. (1980): Times, Spaces and Places. A Chronogeographic perspective. Wiley, Chichester.
Pratt, A.C. (1996): Coordinating employment, transport and housing in cities: an institutional perspective. Urban Studies 33(8): 1357-1375.
Pred, A. (1977): The choreography of existence: comments on Hägerstrand's time-geography and its usefulness. Economic Geography 53 (2): 207-221.
Pred, A. (1981): Social reproduction and the time-geography of everyday life. Geografiska Annaler 63B(1): 5–22.
Ratti, C., Frenchman, D., Pulselli, R., Williams, S. (2006): Mobile landscape: using location data from cell phones for urban analysis. Environment and Planning B: Planning and Design 33(5): 727-748.
Scheiner, J., Kasper, B. (2003): Lifestyles, Choice of Housing Location and Daily Mobility: the Lifestyle Approach in the Context of Spatial Mobility and Planning. Unesco, Blackwell publishing Ltd., Oxford.
Thrift, N. (1977): An Introduction to Time-Geography. Geo Abstracts, University of East Anglia, Norwich.
van der Laan, L. (1998): Changing Urban Systems: An Empirical Analysis at Two Spatial Levels. Regional Studies 32(3): 235-247.
Velký sociologický slovník (1996). Karolinum, Praha.

ANNEXES

Annex 1: Contents of the PhD thesis.

Annex 2: Selected publication of the author.

Publication in journals with impact factor

Temelová, J., **Novák, J.**, Ouředníček, M., Puldová, P. (forthcoming): Housing estates in the Czech Republic after socialism: various trajectories and inner differentiation. Urban Studies. (accepted for publication, i.f. 1.381 in year 2008)

Novák, J., Sýkora, L. (2007): A City in motion: time-space activity and mobility patterns of suburban inhabitants and structuration of spatial organization in Prague Metropolitan Area. Geografiska Annaler 89B (2): 147-168. (i.f. 1,27 in year 2008)

Publication on Web of Science and SCOPUS

Temelová, J., **Novák, J.** (2010, in print): Daily street life in the inner city of Prague under transformation: the visual experience of socio-spatial differentiation and temporal rhythms. Visual Studies.

Ouředníček, M., **Novák, J.**, Temelová, J., Puldová, P. (2009): Metody geografického výzkumu města. In: Ferenčuhová, S., Hledíková, M., Galčanová, L., Vacková, B. (eds), Město: Proměnlivá ne/samozřejmost. Pavel Mervart/Masarykova universita, Brno, pp. 93-128.

Dufková, K., Ficek, M., Kencl, L., **Novák, J.**, Kouba, J., Gregor, I., Danihelka, J. (2008): Active GSM cell-id tracking: Where did you disappear? In: MELT 2008: Proceedings of the first ACM international workshop on mobile entity localization and tracking in GPS-less environments, San Francisco, California, USA, pp. 7–12.

Temelová, J., **Novák, J.** (2007): Z průmyslové čtvrti na moderní městské centrum: proměny ve fyzickém a funkčním prostředí centrálního Smíchova. Geografie - Sborník České geografické společnosti 112 (3): 315-333.

Maps in atlases

Maps in analytical texts in: Ouředníček, M., Temelová, J., Pospíšilová, L. (eds.) (2010, in print): Atlas sociálně prostorové diferenciace České republiky. Karolinum, Praha.

- **Novák, J.**: 6.2 Čas dojížďky 2001,
- **Novák, J.**: 6.3 Čas dojížďky 1991,
- **Novák, J.**: 6.4 Nedenní dojížďka 2001,
- **Novák, J.**: 6.5 Nedenní dojížďka 1991,
- **Novák, J.**, Štych, P., Hudeček, T.: 7.1 Silniční dostupnost,
- **Novák, J.**, Temelová J.: 7.2 Veřejná doprava,
- Temelová J., **Novák, J.**: 8.3 Primární lékařská péče,
- Čermák, Z., **Novák, J.**: 9.1 Saldo migrace,
- Čermák, Z., **Novák, J.**: 9.2 Obrat migrace,

- Čermák, Z., **Novák, J.**: 9.3 Extrémy migrace,
- **Novák, J.**, Ouředníček, M.: 9.4. Migrace mladých lidí,
- **Novák, J.**, Ouředníček, M.: 9.5. Migrace seniorů,
- Ouředníček, M., **Novák, J.**: 9.6 Migrace vysokoškoláků,
- Ouředníček, M., **Novák, J.**: 9.7 Typy migračních procesů.

Novák, J., Macešková, M., Temelová, J., Ouředníček, M. (2010): Dynamika rozvoje obcí (1:500 tis.). In: Hrnčiarová, T., Mackovčin, P. a kol., Atlas krajiny České republiky. Ministerstvo životního prostředí ČR a Výzkumný ústav Silva Taroucy pro krajinu a okrasné zahradnictví, v. v. i., Praha-Průhonice.

Macešková, M., Ouředníček, M., **Novák, J.** (2010): Ekonomické prostředí obcí (1:1 mil). In: Hrnčiarová, T., Mackovčin, P. a kol., Atlas krajiny České republiky. Ministerstvo životního prostředí ČR a Výzkumný ústav Silva Taroucy pro krajinu a okrasné zahradnictví, v. v. i., Praha-Průhonice.

Other contributions

Temelová, J., **Novák, J.**, Ouředníček, M., Puldová, P. (2009): Budou česká sídliště místy bydlení chudých? Era 21, 9(1): 53-54.

Novák, J. (2008): Suburbanizace a doprava. In: Ouředníček, M. (ed.), Suburbanizace.cz. Univerzita Karlova v Praze, Přírodovědecká fakulta, katedra sociální geografie a regionálního rozvoje a Urbánní a regionální laboratoř, Praha, pp. 56-61.

Puldová,P., **Novák, J.** (2008): Suburbanizace a sociální prostředí. In: Ouředníček, M. (ed.), Suburbanizace.cz. Univerzita Karlova v Praze, Přírodovědecká fakulta, katedra sociální geografie a regionálního rozvoje a Urbánní a regionální laboratoř, Praha, pp. 41-53.

Temelová, J., **Novák, J.** (2007): Rezidenční segregace Romů v ČR. Obec & finance 11 (4): 32-33.

Novák, J., Puldová, P., Ouředníček, M., Temelová, J. (2007): Současné procesy ovlivňující sociálně prostorovou diferenciaci České republiky. Urbanismus a územní rozvoj 10 (5): 34-39.