Mobility Pass for Residential Real Estate – An Online Tool for the Calculation of Mobility Costs and the Awareness on Housing Decisions

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1 ABSTRACT

The choice of location for a residence or a business is usually an important, long-term decision requiring a high level of investment of capital. With this in mind, such decisions should be considered together with their consequences, both for the individuals and the city as a whole. "Mobility Pass for Residential Real Estate" is an online tool which investigates the relationship between the selection of the location and the mobility behaviour, showing the effects of mobility time, mobility costs, CO_2 emissions and possible accident risks. Therefore the "Mobility Pass for Residential Real Estate" will be developed for the specific tenant or buyer, for the real estate agents (as a more specific marketing instrument) and for public administration, concerned with the allocation of housing subsidies.

The "Mobility Pass for Residential Real Estate" is designed as a free online tool available on the website www.mobilitaetsausweis.at. This paper deals with the multitier architecture, the basic data used and the routing network to calculate the trips which is the basis for the estimation of the mobility costs.

The project is funded within the IV2splus programme (ways2go initiative) of the Austrian Federal Ministry for Transport, Innovation and Technology (BMVIT). The programme management lies at the Austrian Research Promotion Agency (FFG). The project consortium consists of CEIT Alanova – Central European Institute of Technology, Institute for Urbanism, Transport, Environment and Information Society (lead partner), HERRY Consult GmbH (Consulting in Transportation Planning), Austrian Road Safety Board (Kuratorium für Verkehrssicherheit - KFV) and the University of Applied Science of WKW – Institute for Real Estate Management (Institut für Immobilienwirtschaft der FH Wien – Studiengänge der WKW).

2 RESEARCH BACKGROUND

In Austria, about 10 % of the population changes their home every year, in 2009 that was about 875,000 people. Nearly 80 % (680,000 people) residence changes occur within one or between neighbouring municipalities in Austria. Austria is a country greatly affected by urban sprawl; land purchase is much cheaper in not urbanised areas but infrastructure, from the school bus to the waste disposal, is paid by the public sector.

The population in Austria has increasingly moved outside the main municipalities. Located beside of the city centre most people move around by car and the commuting flows are increasing. It has been stated by the VCÖ (Verkehrsclub Österreich/Association for Transportation and Sustainable Mobility in Austria) that in all Austrian provinces transport is one of the main concerns as the emissions from traffic have increased since 1990 from 33 % to 71 %. The impacts of transport are also reflected in high economic costs, as in Austria every year more than 7.6 billion euro is spent in accident costs and infrastructure.

Looking at the individual scale, the location of the residence has a direct impact on the overall transport behaviour. Already in the 1970s, Torsten Hägerstrand dealt with an analysis of spatio-temporal behaviour of individuals and the depiction of human action in "time paths" (Hägerstrand 1975). The constraints identified by him through the spatial structure result in a manoeuvre, which are crucial to the design of the mobility possibilities and therefore to the possible needs. The "Mobility Pass for Residential Real Estate" shares the same theoretical approach and creates a more transparent and comparable free online tool for those looking for a new house and for the real estate business.

Direct and indirect costs follow the mobility trends, but so do time, CO_2 emissions and accident risk, all strictly related to the distances travelled. The medium and long-term consequences of most people's travelling patterns are still hard to estimate. Most times decisions are made on the basis of short-term decisions such as the price of the rent or for the purchase, the quality of the living according to the available

facilities and so on, without taking into account the costs associated to forced mobility related to going to work or to leisure activities.

While the prices of the rents or purchase and energy costs can be calculated rather easily, the costs and the CO_2 emissions related to the mobility are quite hard to estimate for most people, but often count up for a large part of the household's budget. It was estimated that in 2010 a household in Austria spends EUR 5,240 on average on mobility. A recent study by the VCÖ shows that compared to year 2005, that Austrian households spend EUR 330 more on mobility. The VCÖ indicates that people living in Vienna are paying the least on mobility (VCÖ, 2011). On the other hand, commuters who use public transport to work spend on average EUR 1,800 per year less on travel costs than those who travel by car.

This is why the "Mobility Pass for Residential Real Estate", with the calculation of mobility cost, mobility time and risk of accidents and giving a transparent view of the environmental impact by indicating the CO_2 emissions will help users rethink their habits in a more economic, safe and environmentally friendly way. In the following section the implementation of the "Mobility Pass for Residential Real Estate" concerning the 3-tier architectur and the tool itself will be explained.

3 IMPLEMENTATION

3.1 3-tier architecture

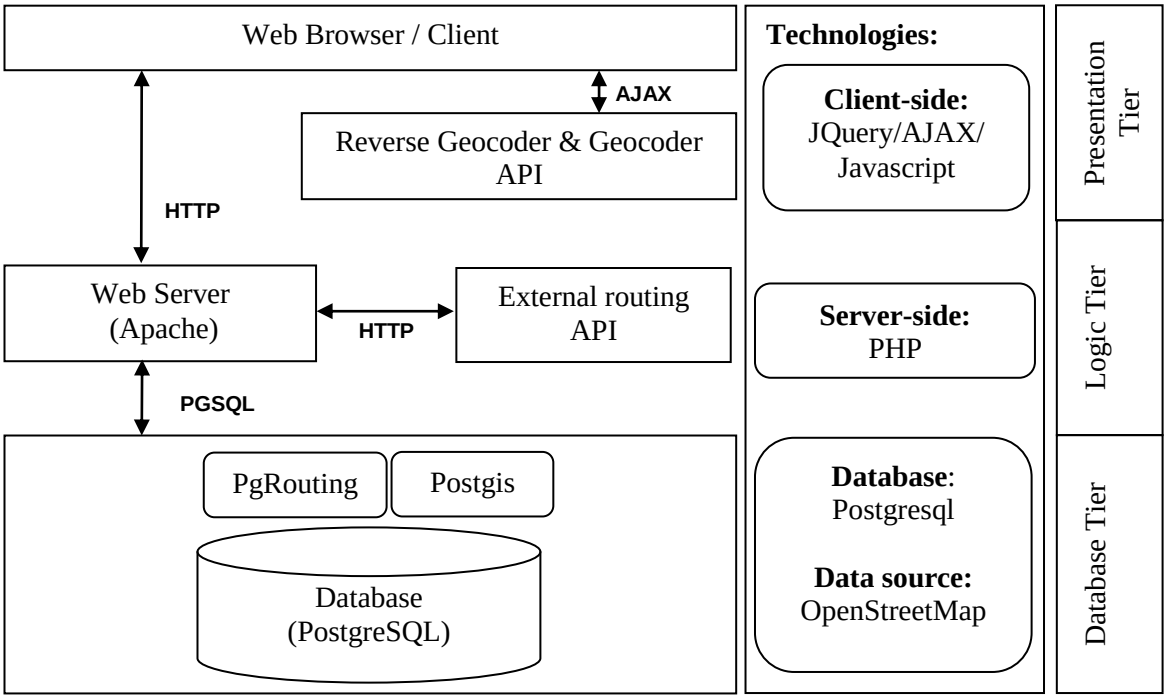

Fig. 1: 3-tier architecture of the "Mobility Pass for Residential Real Estate"

The presentation tier contains the web browser and uses a reverse geocoder and geocoder API to locate the different activities of the user. These interfaces are used to locate the activity places via a map or alternatively by street names. The used technologies for the dynamic components of the online tool are JQuery, AJAX and JavaScript.

The logic tier of "Mobility Pass for Residential Real Estate" provides the intelligence of the application towards the client. For this section the Apache web server with the server-side programming language PHP is used. An external routing API is used to get routing information in foot, bicycle or public transport, which are used to calculate the mobility costs.

The database tier contains the open source relational database management system PostgreSQL and its two extensions. PostgreSQL is extended by PostGIS, which enables the database to support and store geographic objects. With this extension it is possible to store Simple Features (points, lines, polygons) defined by the Open Geospatial Consortium (OGC). The second module PgRouting is used to extend the geospatial database with the functionality of routing.

3.2 Basic Data

The idea for the "Mobility Pass for Residential Real Estate" is to integrate an open and extensible data source. In a prototype version of this tool the individual vehicle transport should be calculated by the street data of Open Street Map (OSM). Open Street Map has the goal to collect all kind of data on a map, like streets, railroads, points of interests, rivers and topographic objects, which are collected under a public license domain. The main advantage of the Open Street Map data are the open source license and the community is updating the map continuously. Open Street Map uses a data model which makes use of topology.

The second data for calculation of the mobility behaviour, which is involved in this project, is the connection to the interface of AnachB.at. The interface is used for the calculation of the route trips of foot, bicycle and public transport and has a multimodal graph. The underlying routing graph of this interface is more detailed than commercial ones and includes live traffic information (Floating Car Data, Traffic Messages …). It gets permanently updated, because it was developed for E-Government and public administration (PRIKOSZOVITS, 2010). The figure 2 shows the online tool of AnachB.at.

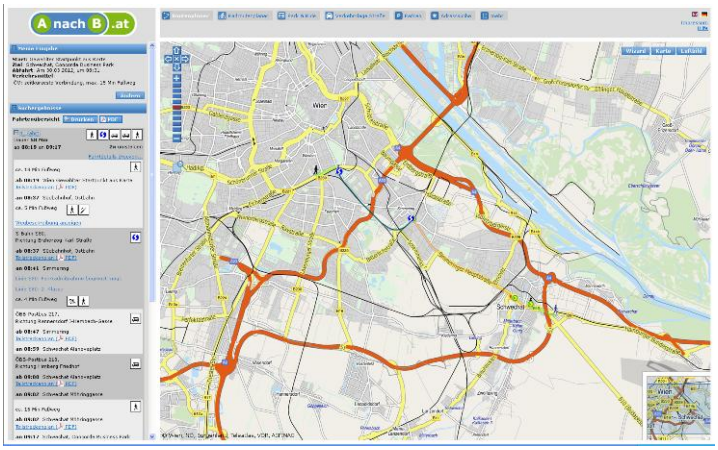

Fig. 2: AnachB.at online routing tool (http://www.anachb.at)

3.3 Routing network and algorithm

The basis for the calculation of the mobility costs are the driving distances between the different activity locations with their different modes of transports. For this the database of the "Mobility Pass for Residential Real Estate" includes a routing network, which consists of a weighted, directed graph. A graph is a non-empty set of vertices where the vertices are connected by edges. The extension of a directed, weighted graph means that every edge is represented by a direction and every edge has a weight assigned. The edges in the routing network represent the road segments and the vertices are made out of the intersections of the road network (DOMSCHKE, 1995).

The weights in the implementation of the routing network of the "Mobility Pass for Residential Real Estate" are defined as the time in seconds needed to pass the road segment, to get the fastest route from one node to another. The seconds are calculated based on the length of the segment and a defined travel time for the individual transport. The tag <highway> defines the different types of roads which exist in the Open Street Map dataset. In a first version only highway tags which are important for car routing are used to define the routing network (motorway, trunk, primary, secondary, tertiary, road, unclassified, residential, living street, service, track, path and the appropriate links). Therefore a travel time matrix was designed in according to the list of street categories.

In Austria, there are fixed general speed limits defined for the different types of road categories. These speed limits are not useful for route calculation, because in the real traffic it is not possible to reach them constantly. Therefore a travel time matrix was designed according to the reference point of the speed limits. Additionally there is a difference of these speed limits in the urban area, which has to be integrated in the routing graph of the "Mobility Pass for Residential Real Estate".

For this purpose, with the help of CORINE Land Cover 2006 data set, there is an attempt to have a delineation of inner-city and non-urban roads. The CORINE Land Cover data set consists of 44 classes (28

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of which occur in Austria). The delineation from the city streets, the main class of "built-up area" and its subclasses are used.

At the preparation of the OSM import data every road segment is spatially analysed via the database. The road segments are intersected with the CORINE Land Cover data set and the definition of an urban road in the "Mobility Pass for Residential Real Estate" is fulfilled if more than 50% of the length of this segment is within the built-up area. The results are all the road data, which exist within the built-up area. With this gain of information, the travel time within the road segments of the built-up area can be adapted for the urban area.

The algorithm which is used for the calculation of the route is the Dijkstra algorithm. This algorithm finds the optimal route between two vertices in a graph. That means the solution is based on the weights the graph is using. Weights can be the length, cost, time, or other things that can be defined on the edges. As above said the "Mobility Pass for Residential Real Estate" uses the time to pass one road segment, so it finds the fastest path from one vertex to another. The idea of the Dijkstra algorithm is to start at the source vertex and searches all next nodes for the fastest edge to the target vertex. The result node is saved permanently and to find the next fastest segment, only the next nodes from the source node or the permanently marked nodes are scanned. If the algorithm reaches the target node it finishes. This algorithm is useful to get the optimal path with a little effort. If the graph is extremely intermeshed, this route calculation algorithm is not the best solution, because it gets slow and it cannot use negative weights, this results into not optimal route outputs. (Universität Oldenburg, 2012)

But also the Dijkstra algorithm is only as good as the graph. For every routing algorithm the database must be defined accurately and updated. In the case of a street routing graph for example it is also important to handle the one-way streets in a pleasant way for the used algorithm. In the routing network of the "Mobility Pass for Residential Real Estate" the edges of one way segments are weighted with extremely high time costs, so that the algorithm never uses them to find a route.

The routing graph of the individual vehicle transport of the "Mobility Pass for Residential Real Estate" covers the whole region of Austria. For the other types of transport modes (foot, bicycle and public transport) the route calculation via the interface of AnachB.at is used.

4 ONLINE TOOL

There are two different versions of the online tool (basic; advanced) which provide different information about the mobility costs. The basic tool should give the user a very quick and rough estimation of the mobility costs and the other output results of an household. An advanced tool also uses the route calculation (Open Street Map, AnachB.at) to get more exact results on the mobility costs, time consumption, CO_2 emmissions and accident risks for an household for a potential new housing location.

The basic tool is designed for people who want to find a rough result with only a few input variables. This tool is only based on standardised statistical mobility patterns. For that reason, a lifestyle matrix was developed out of the micro-census gathering made by Statistics Austria. Based on these statistics, 7 different lifestyle-types could be identified for Austria. In relation to the 4 residential locations (urban, semi-urban, peripheral and 4 cities with special transport infrastructure), 28 lifestyle groups have been established. After that mobility patterns could be classified and assigned to the different lifestyle groups.

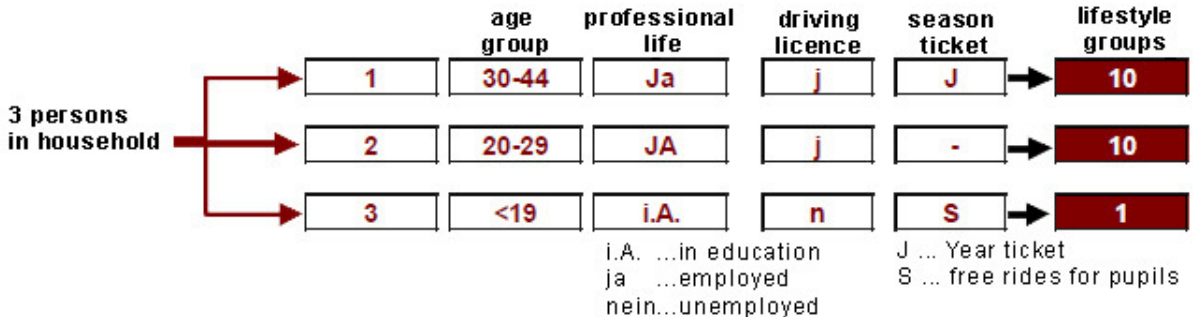

Fig. 3: Lifestyle group classification

Figure 3 shows an abstract assignment of the personal information to a lifestyle group.

The advanced tool of the "Mobility Pass for Residential Real Estate" consists of the created routing network and the external interface of AnachB.at. For the routing calculation, the user has to give information about the different work and weekly regular leisure sites of every person which lives in the household. The locations of the different places can be put directly onto a map or reference them through the input of an address. To any of these locations the user has to select the mean of transport. The kilometers of the different means of transport give the base for the calculation of the different output costs.

Additional in the advanced tool the user has to give some explicit information about the real estate of the household location. For the real estate information the user can choose between a rental object or an object of purchase. Due to this user inputs the tool calculates the annual costs of the object and the user has the possiblity to compare them with the mobility costs. (SEDLACEK N., 2012)

4.1 User Interface

The user interface of the simple tool only offers a few input parameters and a classification of them into three parts. The parts are the area for information about the household location, the mobility information area and personal information area of the household.

The user interface of the advanced module of the "Mobility Pass for Residential Real Estate" is shown in figure 4.

The website is divided into serveral areas. On the top of the tool there is the navigation. The user has the possiblity to calculate two different calculations and compare them against. The current selected site is marked in a different color. Furthermore the main part splits into two parts. The left part is reserved for the input parameters. For the clarity of the various input parameters the area for the information about the real estate location site and the household information are separeted by colors. The advanced tool makes use of a dynamic interface. Due to the inputs of the user new input areas are shown up, so that the user isn't overstrained by the great number of input variables.

The right side of the website contains a map, so that the user can see the different selected site locations.

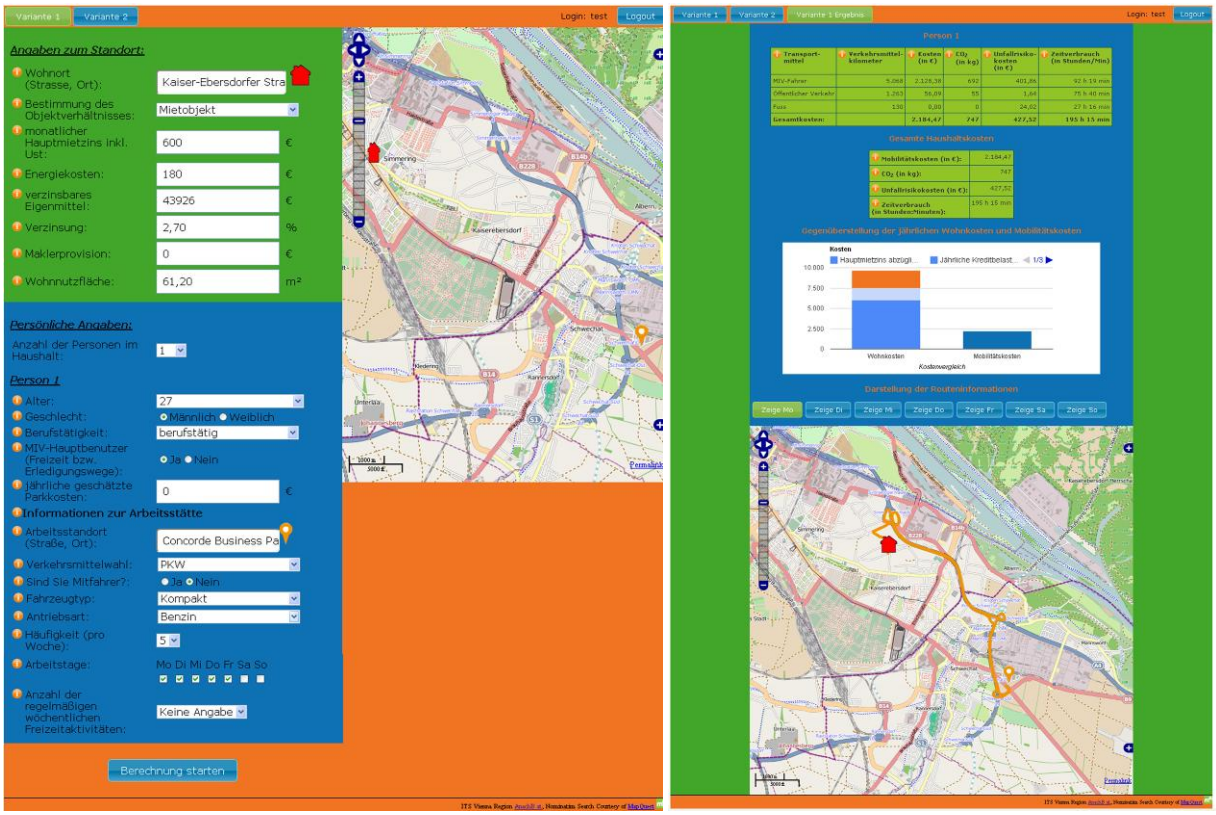

Fig. 4: User Interface (l.) and Result Interface of the advanced tool of the "Mobility Pass for Residential Real Estate" (r.)

4.2 Results

The result mask of the online tool gives information on distance traveled, transport costs, CO_2 emmisions, monitized accidential risk and transport time per transport mode in total for the household. The base for these

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types of costs are the covered kilometers of the overall day trips (work, regulary weekly leisure activities and every day ways) per year. The costs are divided into different groups of transport.

The accident risk describes the calculation of the probability of accidents of certain groups (stratified by age, gender and transport mode) and the determination of a risk score with the help of economic costs of accidents. The variables are not considered isolated but take into account their mutual interaction.

The estimation of the CO_2 emissions in the advanced tool will be calculated on the base of the used transport modality and the distance with the different means of transports. The calculation gives the user a better understanding for his own carbon footprint. Furthermore the advanced tool in addition calculates the annual real estate costs, which gives the user the possibility to compare annual mobility costs with annual real estate costs. The user has also the possiblity to have a look at the calculated routes of this result on an "on the fly" map. The different ways of the various person are colored on a map to get an overview of the ways split day by day (figure 4). The "Mobility Pass for Residential Real Estate" provides the opportunity to compare the result information based on different chosen residential locations and their different mobility costs.

5 CONCLUSION

The "Mobility Pass for Residential Real Estate" is a free online tool, where the results of this tool should give the user a comparison of the rental with the added energy costs of their living place and the user-defined mobility costs. Furthermore additional information about the mobility time, CO_2 emissions and possible accident risk costs are presented to the user. The use of OSM data offers a great source for creating a routing graph with the possibility to integrate continuously updated open source data and it gives the possibility to extend the routing graph to other different modes of transport.

In addition to the mobility tools the tool calculates the CO_2 emissions of the household. Carbon footprints and their calculations have recently drawn attention as they can limit CO_2 emissions of individuals and households based on house, car, and other consumption-related measures. When considering CO_2 emission related to mobility a very important factor to be considered is the residence location.

The important added value of "Mobility Pass for Residential Real Estate" is that it is a combination of a footprint calculator and the calculation on costs, time and accident risk based on mobility. The use of OSM data offers a great source for creating a routing graph with the possibility to integrate continuously updated open source data and it gives the possibility to extend the routing graph to other different modes of transport. The use of the external interface to AnachB.at gives the possiblity to get the calculate routes from a multimodal routing network which is planned to extend of the whole region of Austria. The further development of the "Mobility Pass for Residential Real Estate" can be the optimization of the OSM routing network, the integration of POIs in the map, the improvement of the geocoding service and the integration of ticket prices of public transport.

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