LOGISTICS RESEARCH TOOLS FOR FLEET OPTIMIZATION IN ROAD TRAFFIC[1]

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Summary: *Relatively cheap costs of GPS tracking in combination with modern information technologies and accessible good quality digital maps (GIS) represent new possibilities for development of quality research tools in logistics. With the current economic crisis, increasing fuel costs and considering that the logistics represents a large portion of costs in value chains, the interest of modern companies for investments in research and development of custom fleet optimization tools is increasing. The contribution deals with research in progress of in a project with a road maintenance public service enterprise in Maribor, Slovenia. Issues and approaches are presented in the contribution.*

Keywords: *transportation, logistics optimization, operations research, digital maps, GPS*

1. INTRODUCTION

A logistic system dealing with road transportation activities typically consists of a fleet of various vehicles (specific functionalities, parameters), logistic processes (depending on the purpose of the system) and a road network to operate on. Motivation for investments in research and development regarding system's operations depend on economic situation, while the level of information technology support in the system plays a significant role. A common setting includes integration of company's information system with a service offering up-to-date digital maps (matching the current state of the road network) and a real time GPS (Global Positioning System) tracking service, provided that the tracking devices are installed in all vehicles of the fleet.

2. TECHNOLOGY

The main challenge with digital maps (so-called GIS - Geolocation Information System) include providing up-to-date data in the geometric layer (the base level of GIS) topology layer, as well as in other information layers, which are specific for a particular logistics system (for instance direction of roads, width of roads, critical points, crossroads, pavements, additional infrastructure, elevation, speed limits, distribution plans, etc.).
The main challenge concerning GPS tracking, on the other hand, is to provide a reliable tracking infrastructure. In the era of mobile phone networks, the real costs of a unsophisticated tracking system includes a server connected to relevant software and tracking devices, which

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are nowadays of similar complexity and price range as ordinary mobile phones. Some of the providers of such devices are offering HaaS (Hardware as a Service) payment model. Hence, such a technology is affordable nowadays even for smaller logistics enterprises.
The infrastructure for data collection is thus currently available, which means that the challenges now focus more on so called Business Intelligence, including data organization, transformation, analytics and reporting, providing real-time feedback to support company's processes and provide valuable inputs to management. Additionally, data sets can be often used for providing new services that base on the exploitation of the data collected and processed (for instance, providing the up-to-date network data to other enterprises).
The main goals of the project in progress are: (1) identify possible useable data sources, (2) organize efficient data model for data storage and management, (3) provide relevant business intelligence tools and (4) establish prototype optimization and decision support framework for a chosen complex problem (for instance managing a fleet while plowing the snow in the winter). The project has started in the middle of 2011. This paper briefly summarizes the challenges and some current achievements of the project.

3. DATA LAYER

Efficient modern information systems in logistics represent a continuous challenge. Logistic transactions and data related to the environment in which a logistic system functions are usually represented by large datasets, which have to be handled using special approaches to obtain from them the information of an added value. Nevertheless, it is often the case that in spite of the size, such datasets miss certain information due to improper collection of data or storage saving provisions in the past. Ideally, an information system would have to record every (logistic) transaction and have available the entire environment related information (current state of roads, whether conditions, traffic jams, etc.). Such a system would have to have a large amount of intelligent sensors to collect and process huge amounts of data. Clearly, by using nowadays computer technology, this is not affordable and hence possible. However, on certain data collections more and more advanced specialized applicable services can be built already with the current technologies.
The most important data sources needed to establish data model framework, of course specific to a logistic problem we are trying to optimize, are: (a) up-to-date digitized network, (b) relevant data of fleet (capacity, costs, equipment on the vehicles) and their tasks (distribution, road maintenance, plowing etc.), (c) real-time GPS tracking data and (d) specification of processes involved including their requirements and other constraints (laws, time-windows, detailed process descriptions etc.).
Access to high quality digital maps is currently provided mainly by two international corporations, Tele Atlas[2] and NAVTEQ[3], which offer professional maps with several layers of metadata (category of roads, directions, turns, traffic info etc.); their maps are regularly updated. These maps are essential in professional applications like GPS navigators and other traffic monitoring and guiding systems. Using them involves certain costs that can pose limitations for research use, although these companies offer certain discount possibilities for universities and academic use. But for researchers there are also other possibilities. For instance, a Wiki-like open source project OpenStreetMap[4] provides the access to decent quality

[2] Tele Atlas (TomTom), http://tomtom.com
[3] Navteq, http://navteq.navigation.com
[4] OpeStreetMap, http://openstreetmap.com

digital maps for certain areas, which are contributed by the community under Creative Commons copyright license[5]. In Slovenia, Surveying and Mapping Authority of the Republic of Slovenia established Cadastral register of the economic public infrastructure of the Republic of Slovenia[6] in which the data from geographic information systems covering Slovenian road infrastructure is stored. This dataset contains quite reliable information, but not so many useful metadata for routing planning, like the above-mentioned digital maps services provided by the professional companies. Finally, there is Google Maps[7] service, which through Google Maps API and Google Directions API provides powerful user interface, visualization, geo-location and even GPS tracking visualization support. In particular, the later service represents an important breakthrough in availability of the GIS services for wider public including researchers. It is important to note, that the underlying technology for Google Maps are Tele Atlas maps.

In our particular case, the logistic enterprise involved in the research project is also in charge for local road mapping (municipality of Maribor) which together with the everyday maintenance and supervision services presents an excellent test case for research and development. Hence, our team will be able to work on means of effective logistics supervision, data analytics, optimization, providing instant feedback and transparency for management purposes. In addition such instant feedback opens possibilities for development and testing of various decision support and optimization tools. The company's fleet and processes are specific to their tasks, which are related to the road maintenance activities, and include monitoring the state of roads, cleaning roads, plowing and sanding the roads, etc. All the vehicles of the company have GPS tracking devices installed, which report the current position (GPS coordinates) and velocity of the vehicle periodically in time intervals as small as 15s. The tracking system infrastructure is provided by a specialized provider, who also maintains certain vehicle statistics.

The setting in which the company has simultaneously control over map maintenance and tracking provides an excellent research environment for development of data management, analytic and optimization techniques and thus contribute to overall improvement of the chosen and similar logistics systems. In our prototype data system we use PostgreSQL[8] database with GIS addition PostGIS[9], which is a high quality open source database system. Communication with GPS platform is implemented using Web services offered the GPS tracking service provider's server.

4. SOFTWARE LAYER

In the current state of the project we have made a desktop application in C# language using the library SharpMap[10] with bindings to PostGIS (visualization and management of GIS data) and using WCF (Windows Communication Framework) for communication using Web Services. By using this computer program we provide a minimal basis for further data managing and prototyping.

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[5] CC licences, http://creativecommons.org/licenses
[6] Zbirni kataster gospodarske javne infrastrukture, http://e-prostor.gov.si/index.php?id=240 - in Slovene
[7] Google Maps API, http://maps.google.com
[8] PostgreSQL, http://www.postgresql.org
[9] PostGIS, http://postgis.refractions.net
[10] Geospatial application Framework for the CLR, http://www.codeplex.com/SharpMap

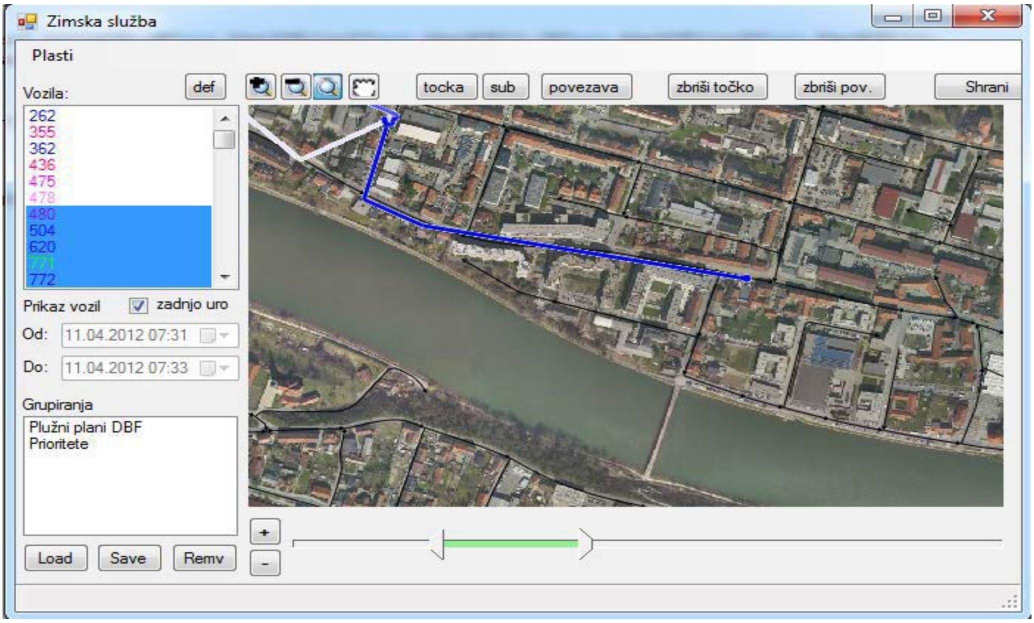

Figure 1. *Screenshot from the current application showing a GPS vehicle position on the digital map with terrain in the background.*

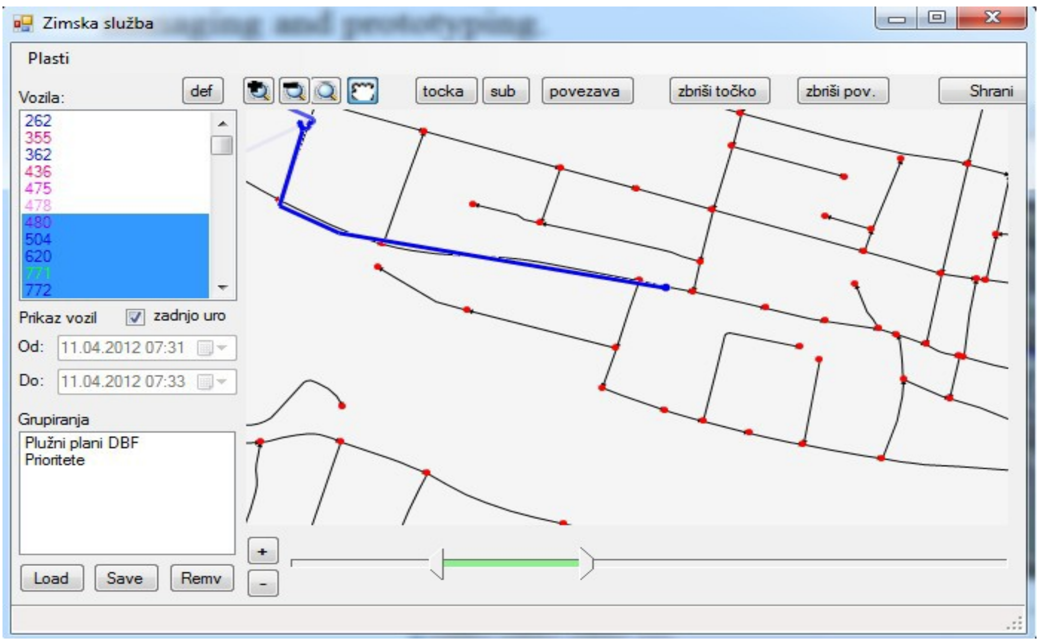

Figure 2. *Screenshot from the current application showing a GPS vehicle and the underlying graph representing the network topology.*

But the challenges of the project do not stop here. One of the partners in the project is the company Abelium[11], research and development, whose main expertises are development of tools for data analysis, data exploitation and optimizations. Using the knowledge obtained through knowledge transfer from the University of Ljubljana, they are developing a powerful network analysis tool net.Plexor, which is based on the past knowledge of a well established academic software for large network analysis Pajek[12], see [1]. The tool is still under development and will be used in further phases of the project to carry out certain advanced data analyses and visualization. Using it, we shall develop specialized analytics and presentation methods, which can be later incorporated in the monitoring and optimization framework. With such a powerful tool combined with other data mining tools, we will address the issues of monitoring of the optimality of vehicle behavior (for instance usage of gas), segmentation of the network for purpose of developing more efficient logistic distribution plans (for instance in snow plowing) and will be able to analyze variations of the plans which happen because of interventions due to external factors (weather change, breaking down of a vehicle, an accident). This will contribute to constant improvement of the logistic distribution plans, which will now with the support of the technology be much more faster and efficient.
Beside the optimization based on the past data, one of the big challenges is how to provide redistribution of tasks for the vehicles in the real time, if priorities in the system change (again due to external factors). A concrete example of a logistics activity will be plowing the roads, where each vehicle has its own plowing plan with priorities assigned to the routes. A large majority of vehicles is plowing simultaneously while a small part of the fleet is on stand-by. If weather conditions change, efficient way of redistributions of parts of the plowing plans has to be carried out.

5. FURTHER WORK

The current result is an implementation of the application which involves a database and integrates various data sources. In continuation of the project, we shall address the analytical and optimization challenges, which will contribute the most to cost-cutting and will enable us to develop the new services through the exploitation of the data. For that, certain new analytic methodologies will have to be developed and implemented.

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[12] Pajek, http://pajek.imfm.si