A Modern Freight Distribution Model for Urban Areas

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Abstract

A goods supply concept of Budapest, in accordance with the European Danube Strategy (EDS), is being researched at Budapest University of Technology and Economics (BME) using optimized route planning based on dynamic travel times. The model can be adapted to freight distribution systems elsewhere, and to city logistics, generally.

1. Introduction

In recent years, the supply of cities, and historic city centres in particular, tend to be more and more problematic. Downtown areas are congested, resulting in environmental damage and external costs. Transportation and freight operations are in a large part responsible for this negative impact on the residents' quality of life, traffic and the environment.

City logistics is a featured research topic at the Budapest University of Technology and Economics (BME). The research on implementation of city logistics solutions in Hungary is one of the priorities of the Vehicle Technology, Transport & Logistics (JKL) research platform of the BME Research University Programme. Ongoing research is about planning an innovative supply system of goods for Budapest downtown. Currently a model is being developed.

As a preliminary research, a benchmarking was carried out among successful European projects. Several were identified as best practices and a possibility to be adapted to our capital.

One such possibility is to utilize the Danube, which splits the city, resulting in bottlenecks in the form of bridges. On the upper hand however, the navigable river provides unused capacity: it is not used to its fullest potential in terms of local goods supply, and sites at the riverbank are vacant in some places. The European Danube Strategy and different local urban development plans address these two problems, meaning development is expected in those areas.

2. The Outline of the Research

The goal of the research is to create a model of a Danube-based goods supply concept which could provide essential input data for city logistics projects carried out in Budapest. The concept is that environment-friendly (e.g. electric) trucks are carried to the historic city centre by barge from Urban Consolidation Storage Centres (UCC) located near the city limits. The trucks are previously loaded by picked units. After docking downtown, the trucks supply the customers (grocery stores, restaurants, bars, hotels etc.) on an optimized route, then return to the barge and the UCC.

A significant reduction of the expected traffic congestions, a positive impact on the environment (emissions, noise), and shorter distances and durations of freight distribution services are expected from the planned system, compared to the present state of goods supply – which briefly means transport individually by each supplier and unloading on the streets. This has to offset and exceed the additional warehousing costs that the inclusion of the UCC to the supply chain causes in order to be economically and financially feasible [1].

Beside the innovative approach the distribution by ship would mean, the difference between the present goods supply practice and the planned one would be the set of products in one transport unit (truck). It would enable to transport goods jointly and not individually by each supplier. The suppliers would unload their cargo at the UCC, and from there, the full order of a destination, e.g. a grocery store would be delivered in one shipment, resulting in less shipping transactions, less trucks and ultimately, less unloading on the streets barring traffic and less congestions on the road.

The model serves as a preliminary research on the implementation of such a system into practical use. It will also provide both strategic and operational route optimization and planning, meaning it will support decision making on a large scale, and allocation of daily tasks as well, by calculating global system parameters and micromanaging the resources.

3. The Tasks of the Model

On strategic level the main objective is capacity planning. It is crucial to best define the ideal number of the UCC(s) and the port(s) and locate them so the system can operate in an economically efficient and feasible manner. The preliminary determination of the number of vehicles needed (considering both barges and trucks) takes place on this level - although it is subject to slight changes during operational planning, because the eventual loading of the pallets, containers, specially designed unit load devices and vehicles affect the ultimate number that is required. Nevertheless, the magnitude of the number of the vehicles needed is decided on the strategic level.

Studies related to the volume and the potential demand indicate that, provided that the destinations would be FMCG shops in the V. district (downtown, see Fig. 1), more than 600 daily shipping destinations are to be reached at the least [2]. It is considered a pilot solution that later may be expanded both in area and in scope of shops involved.

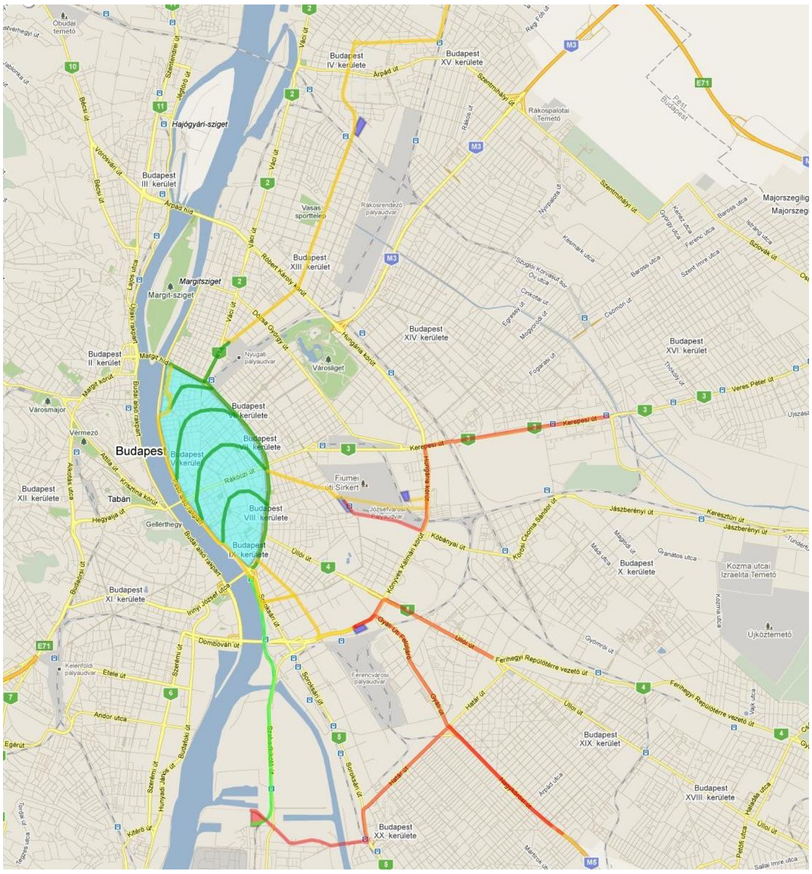

Figure 1: Initial downtown service area highlighted

Operational level defines daily operations. First step is to assess the actual demand. The customers willing to join to the pilot project, that would at first be deployed, are recorded in a database. From this database, the customers to be served will be chosen each day, and the daily operations will include only these chosen addresses.

Each day these customers' locations are assigned to one of the trucks by the algorithm discussed in the next chapter: 4. The Route Optimization. The trucks must be loaded by the appropriate cargo – meaning information systems need to provide and show the connection between the destinations and the products to transport – as soon as the suppliers have unloaded their cargo at the UCC. The trucks then are loaded with the ordered cargo and are ready to be lifted downtown by the barge. From there, they follow an optimized route.

4. The Route Optimization

A module is assigned to create the required input data that the optimization module uses. The desired output of the module should not be the function of the sum of the distance values between the locations alone, but the travel times (a more important factor, if time-related costs are taken into account beside the classical distance-related ones) instead. In addition to this, these values should represent the dynamic, real-time traffic in Budapest in order to provide appropriate data. After extensive monitoring and measurements, a time-map of an area could be drawn. This time-map will provide input data for the route optimization module, so it will be able to project conditions more akin to the real environment.

The solutions of the vehicle routing problem (VRP) provide the basis of the route optimization [3]. A two phase algorithm is used that in the first step forms clusters of the actual customers with a sweep algorithm. Practically, it creates clusters by going in a circle in one direction (a sweep motion, thus the name), simultaneously assuring that capacity constraints are not violated. It then optimizes each cluster as a travelling salesman problem (TSP) in effect, based on the coordinates of the locations. In the latter stages of the research, a module will be developed so dynamic travel times can be used instead of distance values.

5. Conclusions

The model can be improved in numerous directions ultimately. Firstly, it is not developed exclusively for the above mentioned project, but can be adapted to other transport modes, sites and projects as well. It is not necessary to insist on hauling the cargo by barge, it can be replaced by train. Other locations can be used as the input database of the model, if altered accordingly. In that way, the Budapest-oriented project can later be used in other cities and countries.

Secondly, the number of ports (the start and endpoints of the route optimization) can be other than one, resulting in a similar, but more complex multiple-depot vehicle routing problem (MDVRP). Time window constraints can be added to the problem, so that the customers can only be served inside the given time-windows (VRPTW), which makes the algorithm even more complex and requiring significant computing capacity (which makes it dependent on innovative computing methods such as grid-networks or supercomputers). It can be permitted that the electric cars pick up objects (e.g. empties) beside the deliveries (Vehicle routing problem with pick-up and delivery, VRPPD), which is not the case in the original model. Capacity planning changes with that new instalment, since the mass of the cargo is not always decreasing monotonically as the time passes.

It can be said that city logistics projects are successful, remain profitable and in operation only if an exhaustive research – that precisely calculates the demand for such a project, and the capacities that satisfy it, among other attributes – precedes it. In this light, the research exhibited here is essential for the inhabitants, the commuters, the commerce and the environment.

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