

# Innovative ICT Solutions for the Routing and Planning of Multimodal Transportation

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## 1. INTRODUCTION

During the past years the logistic world has observed a trend towards multimodal transportation [1] which is defined as the form of transportation with at least two transport modes. The key idea of multimodal transportation is combining different transport modes - each with their own advantages and disadvantages - to eliminate the disadvantages of certain modes and to benefit from the advantages. While multimodal transportation is already commonly used in personal transportation, multimodal freight transportation still lacks efficient routing and planning algorithms in order to be frequently applied in a logistic environment.

In the next section an overview is given of the IBBT-project MultiTr@ns which is an example of a framework in which this research is applied. Subsequently a multimodal network model is presented in which especially adapted routing algorithms can be applied. After the discussion of the algorithms, some results are presented. Finally, some conclusions are drawn.

## II. MULTITR@NS

In the IBBT-project MultiTr@ns [2] an overall multimodal freight transportation system is developed which tries to realize a breakthrough in the communications between all players in the logistic chain. Three major components can be distinguished in the project: the communications platform, the information tracking module and the planning and routing module.

The communications platform is a multi-agent platform, in which software agents

each representing a player in the transport chain - communicate, negotiate and cooperate.

All freight in the system is supplied with an RFID-tag which can at the same time serve as an identifier or as a node in a wireless sensor network in order to control the freight transport.

The third component of the system makes use of the research presented here. It determines routes from the producer to the distributor, between the distributors and from the distributor to the consumer. For this a multimodal network model is developed on which especially adapted routing algorithms can be applied.

## III. MULTIMODAL NETWORK MODEL

The multimodal network model consists of two views: the layered and the hierarchical one. The layered network preserves the networks inherent to every transport mode, while the hierarchical network reduces the number of routing calculations.

In the layered network a separate layer is assigned to every transport mode, which contains the network of this transport mode. The different transport layers are then interconnected by the means of transshipment links between nodes with the same geographic location. In order to make shortest path routing in this network independent of the transport modes of the origin and the destination a warehouse layer is introduced which contains a node for every geographic location present in one of the transport layers. These warehouse nodes are connected to their corresponding (geographically co-located) nodes.

model is based on hierarchies, presented in [1]. In every iteration the forward construction of a partial shortest-path directed acyclic graph and the backward evaluation of this graph. This algorithm is applied to the layered network viewed as a single large network. It returns a number of levels, of which the higher levels are sparser than the lower levels, while the lower levels contain more details about the network.

## IV. ROUTING ALGORITHMS

In the planning of multimodal transportation there are multiple optimization criteria like financial cost, time, environmental cost ... All these criteria are modeled as costs assigned to every link in the network. If multiple criteria hold at the same time a function of these criteria is used as the cost.

To find a shortest route in a non-hierarchical network the (bidirectional) algorithm of Dijkstra is used. For single shortest path routing in the hierarchical network we adapted the algorithm presented by Schullies [3], which is especially adapted to highway hierarchies, and is based on the bidirectional form of the algorithm of Dijkstra, to a multimodal form.

As we often have multiple optimization criteria in multimodal transportation, a single shortest path does not always fulfill the needs and the attention is drawn to the k-shortest-path algorithms. We focus on the algorithms that find the k shortest paths iteratively. As some of them tend to find paths with a lot of overlap, while others find paths with no overlap at all, we want to control the amount of overlap. This can be done by incrementing in every iteration the costs of the links of the previously found path with a certain percentage. The amount of overlap between the k paths can thus be controlled by adapting this percentage, called the level of difference.

## V. RESULTS

Tests were performed on a multimodal network of Europe with approximately 90 000 nodes and 110 000 links. Once this network had been put in its layered form a 5-level highway hierarchy was constructed.

It can be shown that shortest path calculations in this hierarchy are about 5 times faster than the same calculations in a non-hierarchical network. This is less than Sanders and Schullies could accomplish, partly due to the multimodal character of the network which cannot be optimized that much when building a hierarchy.

In the k shortest path algorithm with a specific level of difference, the amount of overlap can be controlled by adapting a single parameter. Tests have shown how this parameter should be changed in order to accomplish a certain level of difference. It should also be noted that the higher this parameter is, the less optimal the paths found in the next iterations are.

## VI. CONCLUSIONS

For multimodal transportation to be applied in a freight logistic environment, efficient routing algorithms and infrastructure needs to be provided. This article dealt with two aspects of this routing, namely introducing a hierarchy in order to speed up calculations and finding multiple paths between an origin and a destination with a certain level of difference.

## ACKNOWLEDGEMENTS

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## REFERENCES

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