Introduction to the Minitrack

Intelligent Systems in Traffic and Transportation

H.-J. Sebastian
Dept. of Operations Research
Aachen Institute of Technology
Templergraben 64
D-52062 Aachen
e-mail: sebasti@or.rwth-aachen.de

H. G. Nüßer
German Aerospace Center
Transport Research Division
Linder Höhe
D-51147 Cologne
e-mail: hans.nuesser@dlr.de

1. Introduction

Traffic, transportation and logistics are important components of human life. Moreover, they are absolutely necessary for most social and economic activities. Traffic and transportation are both complex areas involving several decision levels, decision makers and customers. Both fields are also characterized by different uncertainties and considerable capital expenditures. To remain competitive, countries and in particular industries must deal with a large amount of data, sophisticated models, optimization techniques as well as powerful computer and information technology. Today's software systems in traffic and transportation are often isolated IT-tools that cannot solve complex large scale problems. The main reasons are that those tools fail to address important constraints, cannot deal with conflicting objectives, do not react to dynamics, and, cannot interact with the user in a timely and meaningful way. However, recent scientific and technological advances in the fields of Distributed Artificial Intelligence, Computational Intelligence, Optimization-Metaheuristics, Geographical Information Systems, Simulation and others allow to build Intelligent Systems, which are able to support decision analysis and problem solving in the field of Traffic and Transportation Systems. Examples of those Intelligent Systems have been elaborated and published during the last years. The HICSS-33 Minitrack "Intelligent Systems in Traffic and Transportation" addresses the Modeling and the Implementation Aspects of Intelligent Systems to solve important real world problems in traffic and transportation.

2. Focus and Topics

Since the beginning of the last century an extraordinary development of transport demand is evident. This is a result of industrialization and the supply of new transport modes which at last enabled substantial changes of economy. The growing standard of living changed living and behavior patterns; faster and cheaper transport modes gave the impulse to see other regions, doing business with partners living farther away, who are able to offer goods cheaper than in the own region.

Therefore the increasing labor distribution in economy, the concentration of population in agglomerations with simultaneous migrations from rural regions, the growing demand for recreation of people being daily stressed in professional life as well as the improvement of rail, road, and air transport supply can be regarded as the principle causes for the enormous increase of demand.

To satisfy the increasing demand for movement, to be economical with the use of public resources whilst encouraging economic growth, requires careful attention to monitoring trends and forecasting. Moreover, growth itself carries dangers. The expansion of transport facilities is not cost-free in terms of the environment and social welfare. A balance has therefore to be struck that satisfies a number of possibly conflicting goals. Such a balance
requires that there are models forecasting the traffic demand and the changes in modal split and travel behavior.

It seems that forecasting the traffic demand and traveling behavior using agent-based simulation will become a successful direction within traffic modeling. The minitrack will contribute three papers which are dealing with agent-based approaches to traffic and transportation.

The minitrack focuses on Intelligent Systems which are able to assist the design-phase (strategic planning) of traffic and transportation systems and/or the management-phase (tactical and operational planning) as well. The purpose of the transportation logistics is to design, to organize and to manage transportation in order to meet customer service demands, cost and environmental requirements. Such logistics systems must comply with regulations on traffic, laws on labor and other types of constraints. In the field of transportation logistics we will focus on the analysis of urban, regional and intercity transportation networks for both passenger and freight transportation as well. Complex hybrid-type systems which include air-, road- and rail transportation as well are of particular interest.

In order to illustrate these types of applications we will consider in the following an example for which an Intelligent System has been developed successfully. This system is in daily use within the Deutsche Post AG.

The increasing market competition and service focus of the customers forces transportation providers such as postal organizations and express shipment companies to re-evaluate and constantly improve their business processes. In the European postal markets this tendency is further amplified by the current deregulation and privatization efforts of the European Union and governments in middle and east European countries. The core service provided by postal companies is package and mail delivery. In this market segment it can be observed that one of the key efforts in the last few years has been a reduction in delivery time. This gives postal companies a better strategic position in comparison to express shipment providers which traditionally have guaranteed short-time delivery. One of the main consequences of these efforts is that the available transportation time has been strongly reduced. On the other hand, the number of transportation requests is usually large while the quantity associated with each request tends to be small. The main problem, therefore, is to balance the requirements of short service times with the needs of low cost operations. These criteria are indeed conflicting and make the planning of the companies’ logistics operations difficult. Both postal and express shipment companies must manage a large fleet of trucks and (sometimes) aircraft to provide such services. The problems encountered are of the less-than-truckload (LTL) type, which means that it is usually possible and – for economic reasons – necessary to transport a large number of transportation requests in one truck or aircraft simultaneously. One must, therefore, consolidate requests at various levels of the system. Indeed, consolidation is the main instrument of cost reduction in the transportation process. The potential to do this is, however, strongly reduced by the tight constraints on transportation time.

The growing complexity of these processes suggested the development of computer-based Decision Support Systems (DSS) in order to assist the planners. A DSS called ISLT (information system for letter transportation) has been developed in the last years for the German post, the Deutsche Post AG. It supports manual planning by providing answers to “what if” type of queries, has modules which support replanning, and implements model-based optimization algorithms, which generate solutions with the help of optimization techniques. It shows many aspects of the Intelligent Systems we are focusing on with this minitrack. An introduction to the ISLT system was presented within HICSS-32.

Intelligent Systems which are designed to solve real world applications in traffic and transportation are built on the basis of an advanced software engineering concept including object-oriented software development and integration with non-standard databases and GIS. On the algorithmic side several so-called Intelligent Techniques coming from the AI, the OR and the CI, such as Tabu Search Metaheuristics, Evolutionary and Genetic Algorithms, Constraint Programming, Agent-based Approaches but also high performance Optimization or Simulation techniques are used.

Therefore, relevant topics for the minitrack include

1. Modeling Intelligent Systems in Traffic and Transportation
   - Models for the estimation of future volume of traffic likely to be affected by planned projects or management policy
   - Models introducing changes in travel behavior
   - Modal split models
   - Transportation Network Design Problems including different modes of transportation and hubs
   - Vehicle Routing and Crew Scheduling Problems (e.g. in air transportation)
   - Dynamic Vehicle Routing and Dispatching

2. Intelligent Techniques applied to combinatorial optimization problems in traffic and transportation logistics
   - Tabu Search Metaheuristics
   - Population-based methods (Genetic and Evolutionary Algorithms)
   - Constraint programming
   - Agent-based modeling and simulation
   - Hybrid methods
Of course, the Intelligent Systems people will develop
differ greatly with the particular application. Therefore, a
mix of modeling approaches and Intelligent Techniques
will appear in the different systems to be developed. The
development of a fully implemented and evaluated system
takes years. Therefore, the papers within the minitrack
need not to present fully developed complex systems.
Conceptual papers, empirical papers and papers dealing
with particular Intelligent Techniques are, provided they
are innovative, within the scope of this minitrack. The
accepted papers cover important fields of traffic and
transportation and represent the typical methodological
approaches which are currently state of the art.

3. Presentations within the Minitrack

There will be six presentations covering different
fields of transportation such as road, sea, air and rail
transportation. One paper, by R. Schleiffer, presents a
multi-agent simulation approach and its application to
traffic modeling. This highly innovative paper considers
autonomous agents that request mobility in an artificial
Trafficland. These agents employ simple rules of behavior
and interaction with each other.

Two of the transportation-focused papers also deal
with agent technology. The paper by H.-J. Bürcckert, P.
Funk and G. Vierke introduces into the TELETRUCK
System. This system supports intercompany planning,
scheduling and monitoring of intermodal transport chains
(railway, road) using intelligent agent technology.

K. Zhu, M. W. Ludema and R. E. C. M. van der
Heijden focus on air cargo transportation. They present a
multi-agent based planning approach.

The other three papers use different Intelligent
Techniques in order to solve problems from different
areas of transportation and implement them in Intelligent
Systems. J. Sauer and H.-J. Appelrath consider Multi-site
Scheduling of an enterprise which runs several distributed
production sites. In such systems transportation of
intermediate products becomes a key issue within the
scheduling process. In order to treat transportation tasks
as scheduling problems heuristic strategies which are
embedded in the distributed knowledge-based scheduling
system MUST are developed.

In sea freight transportation vehicle dispatching at
seaport container terminals is a key problem to solve. J.
Böse, T. Reiners, D. Steenken and S. Voß developed
Evolutionary Algorithms to solve this problem. The
results are tested and implemented at the Seaport
Container Terminal Burchardkai (HHLA) in Hamburg.

In railway transportation scheduling train drivers and
guards is an important problem. L. Kroon and M.
Fischetti introduce an Intelligent System used by the
Dutch railway operator NS Reizigers for supporting their
internal planning. On the basis of a set covering model
they developed a dynamic column generation technique
which represents the state of the art approach for those
types of problem.

The six presentations of the minitrack cover many
fields of transportation and consider one important traffic
scenario. State of the art Intelligent Techniques are used
and, in most of the cases, Intelligent Systems are
implemented and used or tested within projects in
practice.