DELPHI – a joint web decision support application for real time traffic situation analysis and prognosis, information exchange and cooperation

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This paper describes DELPHI, a pilot version of a joint web decision support application for real time traffic situation and prognosis, information exchange and cooperation between the Traffic Management Center, Emergency Rescue Services, the Police and the Emergency Call Center. In two demonstration regions in Germany, Cologne and Munich the R&D project started in 2007. The main purpose is to handle major incidents that affect the transportation situation in conurbation areas. The web application is intended to help task force members at different stakeholders to obtain a common and joint overview. DELPHI also allows to coordinate tactical measures among the task forces.

Keywords: decision support, TMC, Traffic Management Center, incident management, ITS, Intelligent Transportation System

INTRODUCTION

Acts of terrorism, man-made disasters and extreme weather conditions are a threat to modern societies. Managing traffic during the response to a crisis or major incident is a triple challenge: (1) resources in the response operation must be mobilized, (2) movements of people affected by the crisis must be steered, (3) the effects of the population that is not affected must be minimized.

Crisis managers need to decide under uncertainty. They need not only to define locations, routes and schedules for rest centers and cordons, but also routes for the affected population. On top of that, the wider area of traffic beyond the immediate crisis also needs to be considered. Currently these logistic and traffic management decisions are not consistently supported by validated traffic information or decision support systems. Consequently the effectiveness is reduced, since decisions are made on estimations and inexplicit experience instead of validated information and objective data. This is the potential for applying traffic modeling techniques and technologies for traffic management in crisis response operations.

In view of these security risks and economical losses due to man-made and natural disasters the DELPHI-project aims to develop an innovative system in the field of decision support.

REQUIREMENTS ANALYSIS

During the World Youth Day 2005 and the Football Championship 2006, two large events with many participants, the police benefited from using a traffic surveillance and prognosis system, based on airborne traffic surveillance and SUMO, an open-source microsimulation developed by the DLR [1,3]. Based on these experience usergroups were formed in Munich and Cologne. These groups comprise the police, the municipal traffic management agency, the fire brigade, the technical relief (THW), the catastrophe response department and the traffic management department of the government region. The usergroups can be divided in two major subgroups. The first group is interested in functions concerning logistics and transport – THW and the catastrophe response department. The second group is interested in traffic management functionalities. A requirements analysis was made in using the following steps: (1) Problem-gathering during kick-off-meeting, (2) Problem-centered interviews with all end-users, (3) Function development, (4) Validation of surveyed user-problems and needs via email, (5) Validation during user-workshop.

The endproduct of the requirements analysis phase is a written document that describes the user needs and the solutions the DELPHI-system proposes. It was decided to use a web-application that requires very little processing power at the end-user level. This is important since most end-users do not have very powerful computers. The functionality of the web-portal covers seven main functions: (1) Airborne pictures, (2) Current traffic situation, (3) Future traffic situation, (4) Consequences of traffic related actions, (5) Reachability, (6) Route planner, (7) Editor.

SYSTEM DESCRIPTION

The DELPHI system consists mainly of several input streams of traffic and infrastructural data which get refined into a database and visualized in a web portal as depicted in Figure 1.

Traffic Data

Data is gathered from four different sources: First, the available sensor data from loop detectors on highways and urban streets are used. In Cologne, for instance, 781 lane specific detectors from

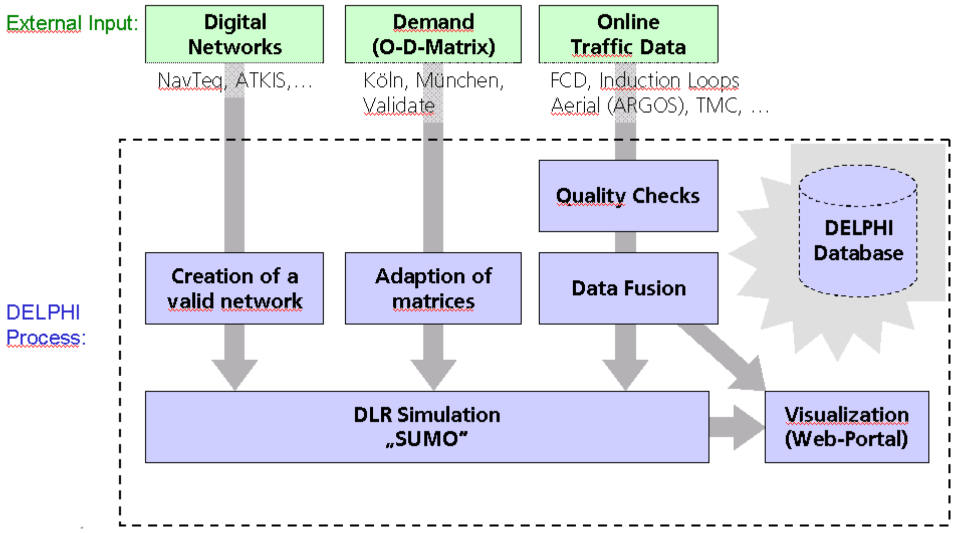

Figure 1: An overview of the DELPHI system

430 sites are available, of which only 629 are actually sending data. 449 of these provide speeds and flows, while the remaining ones provide counts only. The data arrives every minute. It is averaged into 5 minute intervals. Second, there are fleets of floating cars (mainly taxis) which transmit their position at least every five minutes. Furthermore the system integrates airborne traffic data incorporated from a sister project ARGOS, which includes aerial photographs as well as extracted positional and velocity data. Last but not least information about jams and construction sites submitted via the traffic message channel (TMC) is integrated into the portal and the simulation.

Demand Modeling

The required traffic demand in this project is based on the O-D matrices, provided by City Cologne and City Munich. These two O-D matrices were generated in 2000 according to census data. These two demonstration cities are well developed since years and the changes of land use structures are limited. Therefore the modeling technique of estimating current traffic demand with the use of traffic sensor data, gathered in 2008, is applied. With the consideration of the variation of traffic flows the Generalized Least Squared model (GLS model [4]) is adapted. The most likely O-D matrix is then derived by minimizing the differences between the estimated and the target matrices and between the estimated and the measured traffic flows. The respective mathematical form is defined as

$$T = \varphi(T)^{-1}\left(V^{-1}T^{'} + P^{T}W^{-1}\overline{Q}\right) \text{ , with } \varphi(T)^{-1} = \left(V^{-1} + P^{T}W^{-1}P\right)^{-1}$$

where T and $T^{'}$ are the vectors of estimated / target O-D flows V, W are covariance matrices among O-D flows and traffic counts, P is the matrix of link choice proportions and $\overline{Q}$ the vector of traffic counts.

Furthermore, the dynamic user equilibrium traffic assignment model (the oneshot-model [2]) is used for generating the required information of link choice proportions. Respective O-D matrices will then be determined in an iterative estimation process, when the defined convergent criterion is reached. In order to obtain more precise and stable estimation results the applied sensor data are filtered, i.e. extreme values are eliminated, before they are used in the matrix estimation. In addition, related vehicular data, including vehicular ID, releasing times and routes, will be generated as well. Considering different application purposes traffic demand and related vehicular data are estimated for highways and urban roads, respectively. After the generation of daily matrices the influence of disasters and huge events on traffic demand will be analyzed. The estimated time-dependent demand will be used as input data in the traffic simulation.

Traffic Modeling

The open-source microscopic simulation SUMO was enhanced by a mesoscopic module. Instead of simulating every vehicle in each time step, this model divides the road network into cells of 100 metres length (with associated queues). For each vehicle which enters a cell, its departure time is computed. After this time has passed, the vehicle is investigated again, and may proceed to the next cell if a) there is enough place and b) no other vehicle is in front of it within the queue of its current cell. This model was selected since its execution speed outperforms the microscopic model and allows to simulate over one million vehicles in real time.

The simulation is in a test phase now and runs on a single core of a quadcore server using about 3GB RAM. One simulation needs 10 minutes and computes the traffic state for all streets for now and 30 minutes in the future. It is planned to optimize the algorithms in order to achieve an update interval of 5 minutes.

Driving the simulation with online data

The online data consist of flows and speeds at the positions of the detectors mentioned above. While the simulation is fed using predefined routes/flows, the collected data is used to calibrate the simulation. When detector data is available, both the number of vehicles passing the simulated induction loops and their speeds are adapted to the values retrieved. During the prediction phase, where extrapolated values are used, only the predetermined flows are used to drive the simulation.

The adaptation algorithm itself works as follows. The velocities are adapted by assigning new leaving times to the vehicles which are in a cell. Additionally, the maximum velocity allowed in this cell is set to this velocity. The flows are adapted by deleting / inserting vehicles from / into the cell. Inserted vehicles get a route through the network that is taken from the set of previously computed routes. This makes sure, that the distribution of these routes should resemble at least the distribution of the routes with respect to the pre-computed dynamic user equilibrium, and, hopefully, to the distribution within the real network.

CONCLUDING REMARKS

The establishment of the above mentioned decision support system is undertaken progressively. The user analysis is executed and main required system functions are identified. Moreover, an online databank and an interactive web-portal are built and already in service. Users can obtain the current traffic information (travel time, travel speed etc.) by giving a road name or defining a route. Thereto, users can request the fastest/shortest route by giving the respective origin and destination. The other tasks, such as simulation calibration and validation, matrix estimation and data fusion, are currently in progress. A DELPHI-system for simulating and forecasting daily traffic is expected to be established at the end of this year.

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