Scenario Analysis a Simulation based tool for regional strategic traffic management

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THE APPROACH

The development of traffic management strategies starts with a traffic problem situation, defined by the traffic status or events within the traffic network. A concept of action is generated that consists of different single measures to minimise or eliminate the traffic congestions. This concept of action with the various situation-related measures is called a strategy.

Within the regional traffic management the problem situations whose effects cannot be mastered by only one traffic management partner are of special interest. In this case, the corresponding cross-border and intermodal strategies consist of measures from various partners, which need to be co-ordinated.

Improved co-operation and communication between the decentralized organised departments within corresponding region is one goal of the regional traffic management. This is needed to reduce the effects of regionally significant traffic hold-ups or to prevent congestion within a traffic network entirely. The individual technical and organisational constraints of all partners must thereby be taken into consideration. This is where the development of ISM sets in. It enables the management of cross-border and intermodal strategies and the communication between the parties concerned within the traffic management. The Intermodal Strategy Manager ISM, a development within the framework of the Hessian WAYflow-project following the goal to improve traffic management in the Rhine-Main area, supports the planning of new strategies, starting with their impact assessment and coordination up to their implementation as well as the optimising of existing strategies. The advantages of the ISM as a part of the regional traffic management are obvious:

- It is unnecessary to build up an overall traffic control centre and to hand over responsibility from the partners. Every partner is still responsible for his area and keeps the ability to influence the his own measures.
- The ISM development is system independent and allows every partner to decide how and when to conceive their own automatic Strategy Manager.
- The internet based communication is technically easy to implement and requires very little technical or financial effort from the partners.
- The amount of data exchanged is small as no bulk data needs to be transferred.

Above all the common strategies incorporate the regional and temporal diversion of traffic as well as the diversion from road traffic to public transport. The respective measures contain not only the traffic control, such as variable message signs, but also the distribution of information about the current traffic situation to the road users.

The strategies are defined in detail and authorised by the participating partners with respect to underlying problems (e.g. an accident, congestion at a section or major events). With the ISM, these strategies can be analysed and optimised regarding the various interactions with other relevant disturbing factors. If a problem arises it is possible to react at very short notice due to the predefined strategies. The ISM supports the automatic selection of the
corresponding strategies and the verification of the predefined conditions. If the conditions are appropriate the strategy will be activated.

As a result many traffic jams can be prevented if the road users accept the recommendations from variable message signs and traffic information boards set up on the motorways, as well as the traffic information and recommendations from the radio, the internet, or mobility services offered from the private sector.

THE SYSTEM ARCHITECTURE OF THE ISM
The ISM consists of four components, Figure 1:

- the Strategy Manager for strategy selection and online traffic analysis within the strategic network
- the ISM Server for managing the co-ordination processes with the partners
- the Traffic Management Data Warehouse for administrating the strategies and the traffic data as well as
- the Scenario Analysis System for simulating strategies (concept and assessment of new strategies, optimisation and support of existing strategies)

The two components Strategy Manager and ISM Server form the Online ISM since they are jointly responsible for the strategy online processing. The Traffic Management Data Warehouse and the Scenario Analysis System form the Offline ISM which will represent a key element for the optimisation of the network control and the support for the decision making process within the traffic management in the future.

THE ROLE OF THE SCENARIOS ANALYSIS SYSTEM

Figure 1
With the **Scenarios Analysis System** and by the use of a microscopic traffic simulation model built with the AIMSUN simulator:

- new strategies can be defined and evaluated,
- existing strategies may be verified and optimised,
- impact assessments can be done for the strategy or its variations,
- activation conditions can be optimised,
- the effects of road work, events etc. can be examined preliminarily.

The Scenario Analysis System operation is assisted by three auxiliary tools:

- AIMSUN, a microscopic traffic simulator providing the dynamic traffic models for the evaluation of the traffic management strategies, interactively activated from the Scenario Analysis System.
- EMME/2 a transport planning software providing the macroscopic traffic models for traffic assignment and OD matrix adjustment to deal with the analysis of the demand patterns for the selected scenarios.

The main objective of the Scenario Analysis System is to allow the fast and convenient manipulation of input data to create simulation scenarios and to present result data in a compressible way. It has two main components: the experiment specification and the result analysis. The experiment specification includes the set-up of a Problem Network, the modification of O/D matrices, the addition of policies and triggers and the simulator tuning. The result analysis, includes the output data presentation and the comparative study of the performance of a solution, either with previous solutions or with real data. Since a problem can have different solutions and since these solutions cannot be obvious the user can define several experiments combining different policies until he/she finds the best option. During this experimentation the user can reuse previous solutions and add new ones. Then he/she can compare the performance of the new solution with either real data or other solutions. These two components can be used iteratively until a satisfactory solution is found.

These components provide the support for the following main tasks:

- Strategy generation, evaluation and optimisation
- OD-matrix generation and adjustment
- Generation of context-dependent simulated raw data (e.g. “travel times during an special event”)

Within these tasks, strategy-related scenario analysis is the main task, containing

- Scenario analysis of official, predefined strategies to optimise trigger conditions and deactivation conditions (and, by this, to define the road sections that are relevant to monitor trigger and deactivation conditions).
- Scenario analysis to generate new strategies or to optimise strategies that have been defined in earlier experiments.

These strategies are the basis for the management discussions between the various involved authorities to authorise new, additional strategies. After a strategy has been authorised, it is implemented in the Data Base Manager which has the task to administrate all traffic management relevant basic data including strategies, OD-matrices and traffic pattern as well as evaluation-relevant simulated data.
The main tasks in the Scenario Analysis System as illustrated in Figure 2 are

- Get an authorised strategy from Data Base Manager
- Generate interactively a problem area, covering at least the problem net defined in the authorised strategy definition
- Get the Problem as well as strategy ID from authorised strategy definition
Strategy-definition
1. ID
2. Problem (Event; RDS-Location)
3. Trigger (activation of strategy)
4. Condition (deactivation of strategy)
5. Problem Net (\(=\) normal route = list of RDS-loc’s; alternative route = list of RDS-loc’s; additional RDS-loc’s; decision points = positions of VMS and P&R)
6. Policy (measure; coordination partner)
7. Activation Procedure (activate measures)
8. Deactivation Procedure (de-activate measures)

Figure 2
- Get policy from authorised strategy definition
- Get activation procedure from authorised strategy definition
- Get de-activation procedure from authorised strategy definition
Get trigger from authorised strategy definition. - The trigger to activate a strategy is a set of rules describing the recognition of the problem. This set of rules can be modified and extended by the result of scenario analysis.

Get condition from authorised strategy definition. - The condition to deactivate a strategy is a set of rules describing the recognition of situations that require the deactivation, like the problem has been solved. This set of rules can be modified and extended by the result of scenario analysis.

For the definition of the scenarios, it is important to test a strategy in a context that is well known to the authority. This is the case if they have the possibility to analyse a traffic situation that existed in the history, i.e., a specific traffic situation (\(=\) OD-Matrix) in which a specific incident occurred. In the Data Base Manager, the tables of historic road works and historic incident messages are stored such that the Scenario Analysis System can load this list and can offer the selection of a message, fitting to the scenario (related to location and time).

These main tasks can be performed by the Scenario Analysis System, according with the conceptual diagram of figure 3:

- Import of GETRAM global network and related O/D Matrices
- Problem Area definition using a polygon (elements inside the polygon will be on the problem area).
- Edition (change in the number of trips), adjustment (using detector data), traversal (from a global OD), insertion of centroids.
- Strategy definition as rerouting actions, speed limit modifications, closing turning movements, VMS actions, closing lanes, etc.
- Specification and edition of all needed input data for a simulation execution
- Simulation one or more times (replications) of a simulation experiment using AIMSUN2.
- Presentation and analysis of simulation results (statistics and detection)

Figure 3 Scenario Analysis System Conceptual Diagram

The Scenario Analysis System operation is illustrated in Figure 4. In this figure a potential Problem Network is shown. A Problem Network corresponds to a sub-network of the road network on which specific traffic problem may arise or is identified by the user.
The Problem Network is defined graphically by the user opening a window on the screen on which the WAYFLOW network is displayed. The yellow rectangle in Figure 4a corresponds to the selected Problem Network. A Problem Network is characterized by:

- The Road Network within the defining window
- An OD Database linked to the Problem Network with the various demand patterns for the Problem Network under various circumstances (season, day of the week, time of the day, special event, etc.)
- A Strategy Database containing the specifications of the potential traffic management strategies to operate on the Problem Network depending on the identified or potential traffic problem and the demand pattern.

The operation of the Site Creation and Problem Network definition in the Scenario Analysis System is illustrated in Figure 4b, where the Scenario Analysis System working area displays the previously created model of the road network of the site (The WAYFLOW network of Hessen shown in Figure 4a). The rectangle drawn by the operator on the network model corresponds to the Problem Network highlighted in yellow in Figure 4a. Once the Problem Network has been defined the operator activates the extraction of the sub-network model for the Problem Network, this is the first step in the process of generating the scenario to be analysed and the automatic production of the AIMSUN microscopic simulation model to analyse the scenario and assess the potential impact of the proposed traffic management strategies to alleviate the identified traffic problem.

The figure 5 depicts the automatically generated GETRAM model for the Problem Network.
Figure 5. Scenario Analysis System Main Window with the GETRAM model of the Problem Network

The next step consists on the identification of the traffic problem to be analysed. Through the corresponding graphic dialogue the user specifies the characteristics of the problem, i.e. for Problem Network in Figure 5:

- Problem 1: Congestion on section XXX
- Problem 2: Incident in the access to the city spilling back a queue into the motorway

Obviously different, but not mutually exclusive, strategies, one related to each problem may be activated simultaneously. Then the user is in conditions of defining a scenario. A scenario is characterized by:

- The Road Network within the defining window
- The specific OD matrix selected from the OD Database linked to the Problem Network, corresponding to the traffic patterns for which the scenario will be simulated.
- The specific traffic management strategy presumed suitable for solving or alleviated the identified traffic problem, whose impacts are going to be evaluated by simulation

The traffic management strategy is characterized by:

- A Network operational scheme, that is, a configuration defined for instance by specific blocked lanes by road networks, temporarily banned turnings, etc.
- A specific traffic policy, i.e. a set of specific messages for the corresponding VMS panels with the associated actions (information, rerouting, Park and Ride recommendations, etc.), ramp metering on specific ramps, etc.
- Triggers whose threshold values, defined in terms of the selected indices of performance to measure the level of service, activate the operation of the strategies.
After the definition of the simulation scenario the corresponding AIMSUN simulation model is ready to work. The evaluation process is done conducting a set of simulation experiments that can the operator can activate from the Scenario Analysis System GUI. A simulation experiment is characterized by the combination of:

- Simulation modelling parameters
- Selection of a route choice model
- A set of threshold values for the strategy triggers

The comparative analysis of the simulation results for the set of simulation experiments provide the answers to questions like:

- When strategy X should be activated to optimise its impact?
- Which are the most suitable values for the strategy triggers?
- Which would be the expected effects of the strategy in terms of the level of service indices?

The logic of the process is illustrated in Figure 6.

The results of a simulation experiment can be visualized in colour scales an easy interpretation. The operator can identify conflicts and bottlenecks at a glance. Figure 7 depicts a visualization of results corresponding to speeds during a time interval. The traffic variable ton display and the time interval are selected by the operator with the menus of the toolbar. The results analysis in the Scenario Analysis System includes a rich and powerful set of graphic tools to visualize time evolution of traffic variables or measures of efficiency, compare scenarios, and so on, with the purpose of providing the operator with a easy to use decision support tool. Figure 8 illustrates the case of the visualization of simulated travel times on a scenario for a given time horizon.

**O/D Calculation (OD Tool)**

The Scenario Analysis System assumes explicitly that the auxiliary tools, and namely the microscopic simulation with AIMSUN provide the support for a dynamic analysis of traffic scenarios taking into account the time variability of traffic phenomena. That means that the analysis tools require inputs describing the traffic mobility patterns and, if possible, their time dependencies. For example, the proper assessment of the impacts of management
strategies implying rerouting and diversion needs such type of input. A way of providing this input is through the appropriated

Figure 7 Graphic display of simulation results
Figure 8: Visualization of simulation estimated travel times over a given horizon

Figure 9. The conceptual structure of the ODTool and its main functions
OD matrices. The objective of the OD Tool is to provide a module supporting the functions that can generate the requested input. Examples of such functions are:

1. Matrix Edition
2. Generation of the local traversal OD matrix for the selected Problem Network and time period.
3. Adjustment of the local traversal from the available traffic counts for that time period to account for the explicit time dependencies.
4. Modification of the adjusted traversal to account for increases or decreases in the traffic demand at given zones to deal with special events
5. Modification of the adjusted demand to account for addition or deletion of traffic zones (deletion and insertion of centroids)

The high level conceptual diagram of the logic structure OD Tool is described in Figure 8. The diagram shows the correspondence between the main functions.

For edition, OD matrices are presented to the user using a spreadsheet. The user can change any value directly typing on the cell or can apply some basic transformation to one cell or more cells as increment/decrement by a factor or adding/subtracting a constants.

The interactive generation of Local Traversal OD Matrices from the global OD matrices is the function required to provide the inputs to the AIMSUN microscopic model of the Problem Network under analysis. The main input to a route based traffic simulation model is a time dependent origin-destination matrix, each of which OD entries represents the number of trips between the corresponding Origin-destination pair for the selected time period. Usually this information when available concerns the global model of the site being analysed, the WAYFLOW network in our case. This is not usually the case when a Problem Network is selected, unless the Problem Network has been created in a previous phase and its local OD matrix, or traversal matrix in other words, has been saved in a database containing sets of Origin-Destination matrices. Therefore the Scenario Analysis System, in addition to such database has the capability to generate interactively such local matrices combining the versatility of its software architecture with the computational power of the algorithms for traffic assignment and matrix calculations of the EMME/2 software. The main functions of the OD tool as shown in Figure 9 are:

1. Automatic translation of the global network model for the site (the WAYFLOW network in this case) in terms of an EMME/2 model. If link flow counts are available for the time periods corresponding to the global OD matrices for the site, the translated EMME/2 model is prepared to automatically proceed to the adjustment of these OD matrix using the flow counts.
2. Automatic generation of the sub-network model for the Problem Area generated interactively in the Scenario Analysis System, and its translation in terms of an EMME/2 model.
3. Automatic activation of the suite of programs to calculate the Local Traversal OD matrix for the Problem Network.
4. Automatic activation of the adjustment process of the Local Traversal on basis to the link flow counts for links in the Problem Network for the time period under consideration.
5. The adjusted Local Traversal is stored in the Database of OD matrices and exported to the AIMSUN model of the Problem Network as input data for the simulation of the selected scenario in the Scenario Analysis System.
SCENARIO ANALYSIS SYSTEM PROTOTYPE

A Scenario Analysis System prototype is currently being tested previous to becoming operational in February 2002.