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An Approach to Scenario Analysis, Generation and Evaluation

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Abstract

This article presents an operation-oriented approach for traffic management scenario generation, analysis and evaluation. We start taking a few most applied scenarios from a traffic control centre, analysing each component and structure of the whole, and evaluating the impact of each component and some typical combinations, based on available monitoring systems. Carrying on such initial research on best practices, we build a dynamic simulation model, including these typical scenarios and evaluate the impact on traffic for each component and their whole. Evaluation criteria consist of finding an influencing area, and sensible Key Performance Indicators (travel time, delay and environment carbon footprint). This leads to an initial and quantitative expression of the impact of a component. The finding is then applied to other un-tested sets of scenarios and evaluated in the dynamic model. Evaluation is done with both model-based approach and field monitoring. The modelling and monitoring lead to some improved understanding of scenario performance and its generalization towards the implementation in a dynamic model, which hopefully accelerates the real-time automation of scenario selection towards complex or unforeseen traffic situation.

Keywords: scenario analysis; generation and evaluaiton; self learning or rule-based system.

1. Introduction

Traffic management scenarios are the combination of traffic states and appropriate traffic management strategies. The traffic states are characterized by the flows, queues and traffic control. The traffic management strategies are suitable traffic control measures on intersection level, ramp metering control, and information provision to drivers on Variable Message Signs (VMS), radio and on-board devices like smart phones and navigation systems. The methodology that can be developed is very general, applicable in any urban road

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network. The details are specific for the particular network where it is applied and the technical and organizational possibilities.

However, it is still a complicated task for a traffic control centre operator and traffic management practitioners to interpret monitoring data and to pose the diagnosis to an observed problem, due to the complex interactions between measurements, and a lack of insight into network dynamics, in particular when facing non-recurrent situations. It is beneficial for traffic management to provide a decision support tool to these personnel in order for them to be able to select an effective set of measures to a given problem.

Various approaches have been tried and tested, which include rule-based and case-based reasoning, using either artificial intelligence (AI) or expert-based system (Ritchie, 1990). It is still not possible to handle large and complex networks in an urban area. A major difficulty resides in the fact that a specific and real problem at a given location in a large network is hardly easy to be represented and prompted to a readily available solution.

This paper suggests a self-learning approach, which recognises that a solution may not be available to a specific problem but a most likely one may be recommended when experienced successful cases are registered into a relational database. The more the successful cases have been collected, the more efficient the system performs. But it is the restriction also that a case should remain sufficiently robust, so that both generic characteristics of cases and efficient operation of the system can be achieved in balance.

The paper will address further issues in problem recognition, solution matching as well as knowledge database expansion. Note that the paper addresses mainly the technical solutions to support traffic management tasks, and does not deal with the potentially important institutional and usability issues such as the authority and responsibility of the operator and the measure to which this system supports the task execution. One has to expect that the availability of a decision support system changes the tasks of the traffic managers and that, as a consequence, a decision support system has to be adapted in the future to new task performance (van Zuylen 1990).

On-going development in a large metropolitan city, Changsha, China, will be presented. The other case in Beijing will also be reviewed. (Chen et al., 2005).

2. Methodology

The main aim is to be able to propose a best suitable solution to a given (either recurrent or non-recurrent) traffic problem, and to apply it to real-life traffic management. This problem-driving approach requires a fast diagnosis of problems and a quick generation/retrieval of corresponding solutions.

Decision support systems for traffic management can be distinguished in:

[1] Rule based systems, where knowledge stored in structured databases, decision rules (if … then …) and procedures, is augmented with real-time monitoring data. The system can reason about the meaning and consequences of the monitoring data and draw conclusions about the cause of a traffic problem (diagnosis) and the best measures (remedy). These rule-based systems may be made probabilistic (conclusions are drawn with a certain probability) or fuzzy (a diagnosis or remedy are given as membership to certain sharply defined states).

[2] Case-based systems, where an a-priori database is made of situations with traffic conditions and control measures (scenarios). These scenarios are evaluated with respect to certain objective functions. After the occurrence of a traffic situation, the system makes a diagnosis. A match is made between the real situation and the cases in the database. The case that has the best match with the real situation and gives the best performance with respect to a chosen objective is selected and the measures of the scenario are recommended (Hegyi et al. 2000, 2001, Hoogendoorn and De Schutter 2003).

[3] Real-time simulation, where a simulation runs parallel to the real traffic. Monitoring data are used to adapt the simulation to the real situation. The simulation program can run faster than real time and the operator can investigate what will happen in the future if he takes a measure (Mahmassani 2004). A real