DMOTION – ALTERNATIVE ROUTE GUIDANCE SYSTEM BASED ON AN ENLARGED COOPERATIVE WORKFLOW-BASED STRATEGY MANAGEMENT

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Keywords: Traffic Management, Traffic Guidance, Traffic Incident Management

Abstract:

The German research project Dmotion is aimed at developing and implementing an integrated traffic management system for the whole of Greater Düsseldorf. Currently, each road authority is responsible for traffic control within its own territory – namely the City of Düsseldorf operating the urban road network and the Federal State of North Rhine-Westphalia (NRW) operating the motorways.

A strategy management – consisting in situation analysis, workflow system and activity management – needs to be designed to connect both systems to one comprehensive system. The main tool in this process is the so-called ´measure exchange list` which helps adjusting coherent strategies between the partners.

INTRODUCING DMOTION

Dmotion is a German research project within the VM 2010 (Traffic Management 2010) research initiative funded by the German Ministry of Economy and Technology (BMWi). The aim of Dmotion is to develop and implement an integrated traffic management system for the conurbation of Düsseldorf.

The integrated traffic management system is based on a comprehensive data, information and strategy network for regional and local authorities as well as for private service providers. Thus, one major objective of Dmotion is to generate a consistent and comprehensive report on traffic conditions for Greater Düsseldorf. The provision of an overview on the current traffic situation is a precondition for deciding on corrective actions. Therefore, the involved authorities have to agree on certain measures to be taken in case of incidents. These traffic management measures are combined to so-called ´comprehensive strategies` and lead to traffic streams being diverted and road users being advised to use alternative routes. The information will be provided to road users via roadside information systems (VMS), available on the internet and, additionally, provided through online navigation by private service providers.

Private service providers will be linked to include the agreed strategic advice of public authorities in advanced navigation systems. This so-called ´strategy conform` routing will guarantee consistency between collective and individual information services.

This paper focuses on the Dmotion strategy management with different road authorities. The latter are meant to detect incidents, automatically agree on suitable measures and monitor their implementation for the conurbation of Düsseldorf and still keep their sovereignty.

INITIAL SITUATON

The City of Düsseldorf has to cope with an extremely high level of commuter traffic. There are over 400.000 people commuting by car to the city every day, mostly for occupational reasons. In addition, drivers from the Greater Düsseldorf are attracted by numerous cultural events and excellent shopping facilities.

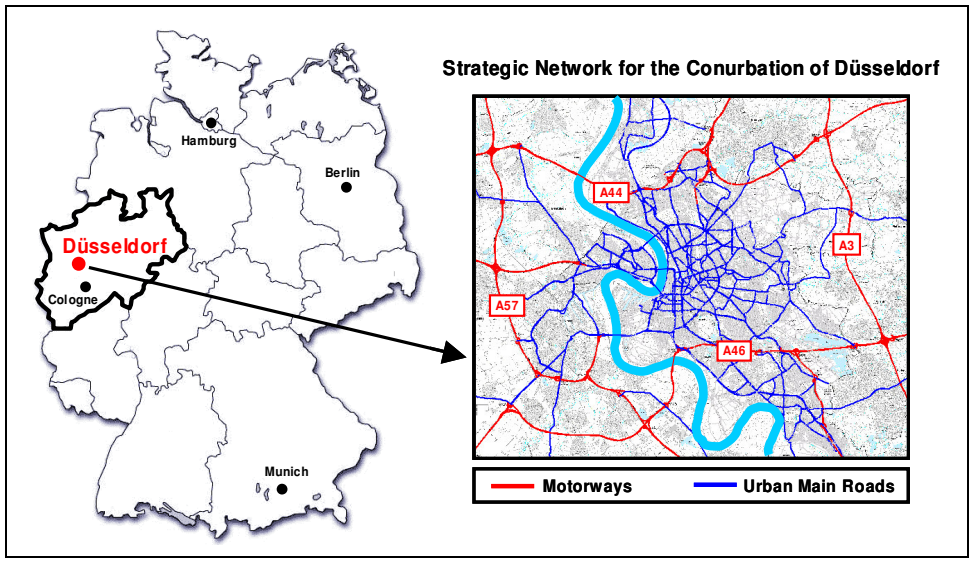

Figure 1. Strategic Network for the Conurbation of Düsseldorf

A motorway ring surrounds Düsseldorf, comprising the motorways A57, A44, A46 and A3. The A3 and A57 are also highly frequented by supra-regional traffic. Furthermore, there are numerous radial arterial roads. For the regional classification see figure 1.

This road network provides an excellent prerequisite for creating a comprehensive traffic management system for the city and its metropolitan area. Within the scope of the Dmotion project an effective, sustainable and strategic traffic management system is to be set up for the City and the urban agglomeration of Düsseldorf. Besides the City of Düsseldorf and the Federal State of North Rhine-Westphalia, private providers of mobility services are also involved in the project.

At present, each road authority is responsible for traffic control within their sovereign territory, using different control and information systems. The motorways are operated by the Federal State of North Rhine-Westphalia, with the traffic control centre situated in Leverkusen, whereas the urban road network is operated by the City of Düsseldorf with its urban traffic management centre. So far, traffic conditions in the neighbouring network have always been left out of consideration when taking decisions on any traffic management measures. Within the Dmotion project, both systems will be connected to each other to provide one comprehensive strategy management system.

OBJECTIVES

Considering the user needs of the involved authorities, a strategy management has to be designed which fulfils the following objectives:

- Automatic selection and implementation of pre-defined comprehensive traffic management strategies
- Partnership of equals for the involved authorities
- Generating an overview on the current traffic conditions for the road network of each authority's responsibility
- Evaluating current traffic conditions for the road network of the responsibility of each authority
- Each authority keeps the sovereignty of actuating dynamic traffic signals, variable message signs and related roadside equipment within its own network.
- Ability to expand the solution in order to include other authorities

A workflow-based system has been specified that provides an online adjustment of coherent strategies taking into account operational and strategic requirements of the involved partners.

SOLUTION

Planning Process of Strategies

At the beginning of the realisation of a cooperative strategy management a detailed planning of integrated strategies is required. Additionally to the calculation of capability and the derivation of accompanying measures, this first step of traffic planning comprises the identification of activating and blocking conditions. An activating condition is the increase of traffic volumes above a determined threshold value or a LOS which describes congested traffic conditions.

Again this requires a full analysis of the current state with regard to existing detection and actuating elements (traffic signals, VMS) on selected main and alternative routes. Therefore, for the cooperative strategy management an integrated report on traffic conditions is an essential requirement.

In the process of planning, the total amount of strategies and their effects to each other need to be considered. Conflicts and corresponding methods of resolution need to be identified between several strategies. Here one must distinguish between

- global and
- local conflicts.

Global conflicts occur if at least two strategies have a controversial intention as regards content. These conflicts have to taken into account before planning individual strategies. Possible conflicts have to be identified and excluded from the strategy provision.

Prioritising global conflicts can result from traffic, political or economical aspects and objectives. Within a cooperative strategy management it is important that these specifications consider the interest of both authorities.

Local conflicts occur if at least two strategies demand different actions from the same actor (e.g. VMS) at the same time. Here it is necessary to differentiate if an obligatory or a non-obligatory action is to be implemented. In this context, obligatory is defined as mandatory necessarily in order to implement a strategy.

If a conflict exists between two obligatory actions, it will be resolved by a predefinition of a hierarchy of prioritisation. This prioritisation will define which strategy will be established.

Predefined conflict matrices build the basis for a decision on prioritising, the local conflict matrix of the city (traffic signals, VMS on arterial roads etc.) on the one hand and the local conflict matrix of the Federal State (VMS on motorways, stretch control system etc.) on the other hand.

Semantics of Strategy Negotiations

To adjust coherent strategies between the partners, a so-called ´measure exchange list` is established.

With the measure exchange list, every partner publishes event-triggered and/or in fixed time intervals which strategies are currently available to be requested by the other partners. Only those strategies are marked as available that imply the direction of traffic streams via road sections with idle capacity. It is necessary that these strategies do not access actuating elements currently defective and that they do not contradict the currently implemented strategies. A measure exchange list is continuously and automatically generated and published by the workflow system of each partner. Therefore, a pre-filtration of requested strategies is carried out on the part of one partner.

This measure exchange list is a fundamental attribute of a cooperative strategy management. Besides the transparency between the partners in the process of coordination, data exchange between the traffic management centres decreases as a result of this method of communication. Thus, an essential user requirement of the operators of the supra-regional motorway traffic centre was met. In the event of a coupling with additional conurbations, a data exchange would be expected with a quantity of singular messages impossible to handle for the operators. Therefore, with the measure exchange list this effect is minimised.

From a technical aspect, the measure exchange list is a status vector which holds information on condition (activated/not activated) and availability (available/not available) of all measures offered by a passive authority.

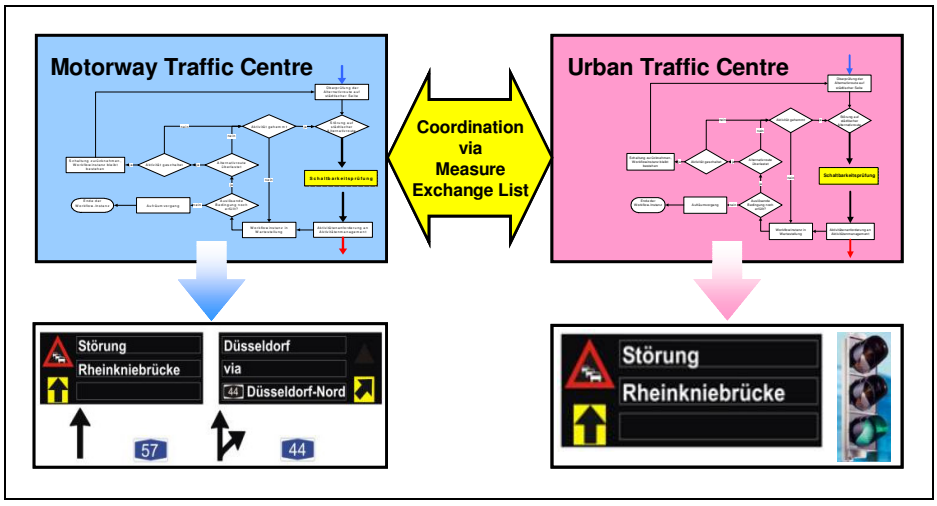

Figure 2. Strategy Negotiation

The semantics of strategy negotiations rely on the following logically and constitutive steps:

1. Congestion detection or report of an incident in the area of an authority. This authority therefore becomes the ´active` partner and an activating condition will be initiated through this incident.

2. First verification on the basis of the measure exchange list

3. Measure request of the active partner at the traffic centre of the passive partner

4. (Positive/negative) confirmation of the measure request

5. Implementation of action (initiation of VMS) at the centre of the passive partner; if successful, implementation of action at the centre of the active partner, too

6. Ongoing control of activating requirements and correct conditions of the activated strategy

These semantics outline the essential requirements which are retrieved in the logical architecture and the software architecture. This is reflected in the components of the strategy management software.

Implementation into a Strategy Management Software

The strategy management consists of three components (see figure 3), which are implemented in the centres of both public authorities:

- Situation Analysis
- Workflow System
- Activity Management

In the algorithmic process flow, the situation recognition reflects selected integrated strategies via determination of activating conditions.

Within the situation analysis, the system detects incidents in the network. If a strategy has been pre-defined for a certain type of incident, an allocated workflow is activated. To guarantee the sovereignty of the involved authorities, each centre is equipped with its own independently performing situation analysis. The situation analysis is confined to their own sovereign territory.

The situation analysis identifies a need for action and initiates workflows. Thus, workflows are only activated when an incident is detected in the own network. Within a single traffic management centre, there is no need for a complete overview of the current traffic conditions in the whole network. The authority that detects an incident and activates a workflow is called the ´active partner` within the further process of adjusting a comprehensive strategy.

Once a workflow has been activated, the workflow system verifies if the intended strategy can be implemented. Therefore the system checks (for the network of its responsibility):

1. the capacity of the alternative routes,

2. the technical availability of actuating elements needed to implement the strategy (e.g. VMS, traffic lights) and

3. if contradicting strategies are currently implemented.

Furthermore, the workflow system monitors if the triggering conditions (e.g. a detected incident) still exist.

In the context of the following activity management, a definition of actions and parameters for conflict approaches is set. The activity management requires measures from the passive authorities, implements the strategy in the own network and monitors the implementation.

On the part of the City of Düsseldorf, the activity management verifies the technical availability and it confirms the logical availability with the local conflict matrix. The same procedure is applied for actuating elements on the part of the federal motorway via a provided measure exchange list.

The process between the two modules of strategy management software (urban and motorway control centre), to implement a strategy with two partners being involved, is defined as follows:

- Incident detected by active partner ⇨ activation of workflow
- Workflow checks if intended strategy can be implemented regarding the current conditions in the network of the active partner
- Workflow checks if passive partner has published strategy to be available
- Active partner requests strategy implementation from passive partner
- Passive partner checks availability again and returns positive or negative confirmation
- In case of positive confirmation, both partners start to implement the intended strategy

Both partners continuously monitor the implementation of the intended strategy. Furthermore, the active partner checks if the triggering incident still exists.

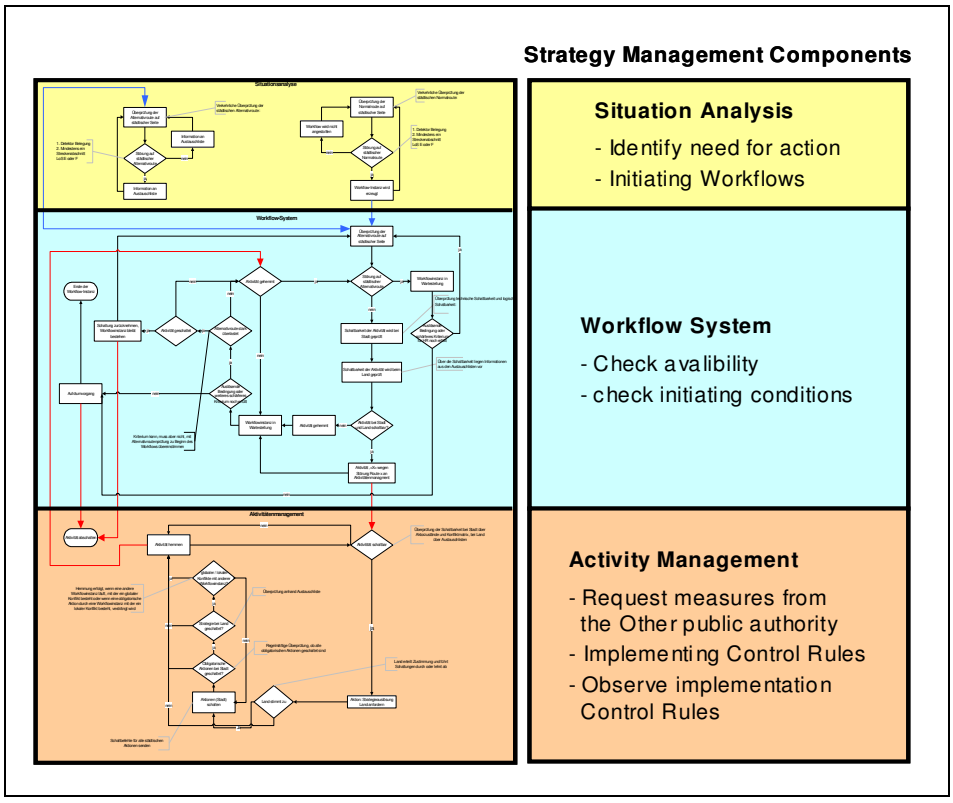

Figure 3. Components of the Strategy Management System

CONCLUSION

The strategy management as specified and developed in Dmotion provides an interoperable solution for adjusting and implementing traffic management strategies, comprising the networks of multiple authorities.

At the same time the authorities involved keep their network sovereignty. Therefore, an isolated approach arises from the network of equal partners.

A continuous coordination via measure exchange list leads to a reduced need of communication between the traffic management centres. The mutual exchange of available actions gives both partners the possibility of a pre-filtration of requests within their own systems. So the total number of requests is reduced to a minimum.

Especially for the supra-regional centre (here: motorway control centre) this is of particular interest. It guarantees that additional conurbations may be connected to the motorway control centre – which operates state-wide – without creating a flood of non-operable requests.

The fundamental cooperation model consists of the fact that an abandonment of competence won't be necessary between partners. By this means, transferability to other conurbations with a different structure is always possible.

In the operating model, the degrees of freedom provide a main advantage. Each partner is able feed his own system and each partner is free in the configuration of his own situation analysis. Therefore the flexibility of the technical characteristics for the partners remains.