FUEL EFFICIENCY IN COOPERATIVE NETWORK CONTROL SYSTEMS

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ABSTRACT

Current adaptive urban traffic control systems generally seek to minimize delays in the network. Some adaptive urban traffic control systems can take the number of stops by vehicles into account. The latter can be used to limit fuel inefficient accelerations. The impact of a stop of a fully laden truck is much higher than that of a light weight car. By using the emerging cooperative systems technology it will become possible to minimize fuel consumption based on actual vehicles characteristics. The cooperative interaction is twofold. Firstly, the urban traffic control systems gets real time insight in the vehicle characteristics through which control can be optimized. Secondly, the urban traffic control system can give feedback on optimal acceleration patterns to individual drivers or vehicles.

Key Words: Cooperative systems, CVIS, urban traffic control, fuel consumption, emissions.

INTRODUCTION

Road traffic uses a lot of fuel, produces carbon dioxide, noxious emissions and noise. All of these depend on the driving characteristics. In the urban context, vehicle acceleration is probably the most important variable factor in emission and fuel use characteristics. In an urban network, the stops at intersections and stop-and-go behavior in congested road segments are the main causes of acceleration. Urban traffic control systems can have a big influence on these factors. In (1) a test is described in which a non-optimized versus an optimized green wave system are compared with respect to noxious emissions and fuel consumption. In the optimized green wave situation, the fuel use was reduced by a quarter, while NOx was reduced by 50%. These are very significant improvements.

Heavy goods vehicles have a big impact on total fuel use and emissions. They also have a significant influence on the details of the control on intersections. Due to their lower acceleration they leave gaps in platoons and limit traffic flows. The details of which depend on where heavy goods vehicles are in a queue. For these reasons heavy goods vehicles warrant special consideration in the details of the green time optimization at intersections and in the coordination between intersections. This can be done quite locally in an ad-hoc optimization scheme at key intersections, but can also be done as an integrated part of an adaptive urban network control system. In the latter case, the queue models need to be extended and the cost functions for the optimization in the network need to contain more detail.

The traffic details needed in the extended queue models and cost functions can be obtained by an extended traditional detection field and by direct communication with vehicles through the emerging cooperative technology. The traditional detection field in urban traffic control will generally only detect presence, volumes and sometimes speed. By extending it with vehicle classification, vehicle type sensitive control can be achieved. Cooperative technology, however, can deliver much more detail. It can give information on the actual weight and load of vehicles and the engine type. A further advantage of cooperative technology is to give speed and/or acceleration advice to drivers.

COOPERATIVE SYSTEMS IN URBAN TRAFFIC CONTROL

<<Final paper gives a description of work done in the CVIS EC-funded integrated project>>

CVIS PRIORITY APPLICATION

<<Final paper will describe the CVIS Priority application as it is being developed. The Priority Application can be used as the basis for control that takes fuel consumption and emissions explicitly into account>>

CVIS PRIORITY APPLICATION FOR FUEL EFFICIENCY

To be able to reduce fuel consumption, the algorithms in local or networked adaptive traffic control need a way to value the impact of potential control strategies. Generally to do this a cost function is used in which all relevant objectives for control are represented. One of the current research activities is on how to represent fuel efficiency accurately and economically in the cost function.

The cost function is but one part of the control algorithm. Another part of the algorithm is the ‘solution guessing’ part that generates potential control solutions that can be evaluated through the cost function. There are many possibilities for the ‘solution guessing’ part. They range from a simple smooth continuation of the past to a ‘comprehensive’ search of the solution domain by for instance genetic algorithms.

Furthermore, the actual situation has to be accurately represented in such a way that it can be used for short term predictions depending on the different control solutions. Part of the current research is directed towards extending traditional queue models that only give the length (in vehicles, time-to-clearance or meters) of the queue towards a model that includes details on the vehicles that are relevant for energy savings and emission reduction.

In the CVIS priority application the queue model is being extended with vehicles types and their priority levels. Still more extensions of the model are needed to include fuel efficiency in a comprehensive manner.

<<The final paper will give additional information on the queue model and the cost function>>

SIMULATION

The number and complexity of optimization criteria for adaptive urban traffic control is increasing. With the possibilities that cooperative systems bring, it becomes very complicated to balance the various optimization criteria. The following list gives some idea of the complexity:

- Delays for pedestrians, bicycles, private cars, heavy goods vehicles, public transport and emergency vehicles.

- Fuel consumption (where vehicles types, load and acceleration profiles could be taken into account).

- Noxious emissions (again influence by vehicle type, driver behavior and load).

- Importance of specific routes in the network. Some routes are to be managed such that their capacity is maximal, some have to be relatively traffic free and some have restrictions on vehicle types.

Control algorithms that balance these factors might give rise to control solutions that have an influence on perceived quality and safety. When e.g. a green light is extended to avoid a stop of a heavy vehicle, a gap in the traffic flow might occur. Such a gap can lead to irritation to conflicting traffic and in the worst case it can lead to unsafe crossing behavior.

To be able to evaluate these factors, extensive simulation is needed to validate the actual efficacy of the algorithms and the potential side effects for perceived efficiency and safety.

In the context of the CVIS project a micro simulation environment has been set up that can model the detailed interaction of vehicles with the infrastructure based distributed urban traffic control. The Helmond test site in The Netherlands, where the CVIS Priority application is tested, is modeled in the micro simulation environment.

<< The final paper will give the first simulation results including fuel efficiency estimates>>

FUTURE RESEARCH AND TRIALS

Predicting the behavior of a system that balances many optimization criteria is extremely hard. Currently only micro simulation is viable. But as there are very many parameters, micro simulation takes an inordinate amount of time. To be able to see whether the investment in a cooperative systems environment or one with an extended classical detection field is sound, it would be useful to have a way to make an analytical estimate of the benefits.

The biggest benefits are achievable with a high penetration of CVIS-enabled vehicles. The planned trials are very small scale. They will only be able to show the technological aspects of the cooperative systems. To be able to show the full impact the new algorithms, larger trials are needed that incorporate more CVIS-enabled vehicles and cover a bigger network. An extended traditional detection field can help speed up the process.

REFERENCES

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