Akcelik & Associates Pty Ltd
PO Box 1075G, Greythorn, Vic 3104 AUSTRALIA
info@sidrasolutions.com

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REPRINT

Route Choice and Signal Control: The Potential for Integrated Route Guidance

RAHMI AKÇELIK

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NOTE:

This paper is related to the intersection analysis methodology used in the SIDRA INTERSECTION software. Since the publication of this paper, many related aspects of the traffic model have been further developed in later versions of SIDRA INTERSECTION. Though some aspects of this paper may be outdated, this reprint is provided as a record of important aspects of the SIDRA INTERSECTION software, and in order to promote software assessment and further research.

Route Choice and Signal Control: The Potential for Integrated Route Guidance. Tom Van Vuren and Dirck Van Vliet. (Institute for Transport Studies Series, No. 5). Avebury, Ashgate Publishing Ltd., Gower House, Croft Road, Aldershot, Hampshire GU 11 3HR, England. 1992. 222 pp + xii. ISBN 1-85628-289-9. (Also available from Gower Publishing Co., Old Post Road, Brookfield, VT 05036, USA). $59.95.

Most design work for urban traffic facilities is based on the use of constant arrival (demand) flows, ignoring possible effects of traffic control (supply) on flow patterns and levels. On the other hand, the assignment of traffic demand to a network, as a basic step in the transport planning process, is traditionally carried out with a given set of traffic control conditions. The combined traffic assignment and control problem has been studied in the past, but this important subject is likely to receive more attention in the future because of the increased emphasis on demand management (Luk, 1992) and route guidance in intelligent vehicle-highway systems (FHWA, 1992) and because it is so fundamental to the modelling of traffic in urban areas.

Van Vuren and Van Vliet present an extensive study of the combined traffic assignment and control problem. Specifically, they deal with this problem in the context of network design and dynamic route guidance. The authors should be congratulated for successfully dealing with such a complex topic. They clearly state the objectives, assumptions, and limitations of the study at the outset and provide useful summaries and discussions which qualify their findings at the end of each section and in the last chapter of the book. One criticism of the study is that it is limited to the use of methods developed in the United Kingdom; the authors miss out on international developments that are potentially very useful in this research.

The strength of the book is more in traffic assignment than in traffic control. It deals with signal control only, and more importantly, with the design of green splits in an off-line fashion. Although the context of the study is defined as traffic responsive control, the various control strategies it considers, as well as the associated models, are of a fixed-time nature and not real vehicle-actuated control as we know it. The problem in real-life networks is even more complex considering the existence of roundabouts and sign-controlled intersections interspersed with signalized intersections; these make the dynamic control of traffic even more difficult.

The study does not deal with the most important parameter in signal control: the cycle time. This reviewer's work two decades ago (Akçelik, 1974) indicated that the most beneficial effect of route control in a signal-controlled network was to reduce the cycle time at the critical intersection by diverting, for example, a critical turning stream away from that intersection, resulting in benefits to traffic at many intersections in the area.

A critical assumption in traffic modelling is the use of constant saturation flows. In real-life networks, such factors as opposed turns, short lanes and lane blockages in shared lanes result in decreased saturation flows with increased cycle times. This fact is still neglected by those who follow the traditional traffic models that were primarily developed for simple manual calculation purposes. To some degree, the SATURN model used for simulating the real-life networks in this study appears to allow for such capacity losses.

The green split policies considered include the equal degree of saturation (EQUISAT), minimum delay and equal "saturation flow-weighted delay" policies. It would have been useful to test such green split policies as unequal degree of saturation (higher degrees of saturation to minor routes) and major route priority. The latter is relevant to the case of a given cycle time as used in this study and is particularly important in the case of coordinated signals. Methods for calculating green splits using these policies have been described by the reviewer (Akçelik 1990) and are not much more difficult than the application of the EQUISAT method.

Recently, methods for estimating average green times and cycle time under vehicle actuated signal operation with different types of signal controllers have also been developed (Akçelik 1993). It would be interesting to study the combined traffic assignment and control problem with true vehicle-actuated signal operations since the implied degrees of saturation are unlike those assumed for fixed-time signal analysis.

Interestingly, in Chapter 2, the authors state that the SCOOT traffic responsive control system developed in the United Kingdom uses the EQUISAT method for calculating green splits, and in the final chapter, conclude that this policy is now obsolete, mainly because it performs poorly compared with the minimum delay settings, and is found to be unstable. The authors express this conclusion in the context of the combined traffic assignment and control problem, not in discussing the SCOOT control system specifically.

The travel time/cost models used in this study are the well-known BPR function, Davidson's function, a function incorporating Webster's steady-state delay equation, and another function that incorporates the time-dependent equivalent of Webster's function. The time-dependent delay model appears to be based on the correct definition of delay for traffic assignment purposes, namely the delay to vehicles arriving during the flow period including any oversaturation delay experienced after that period. However, it appears that there is a typographical error in Equation (2.36): replace $B = fT/c^2$ by $B = f/(Tc^2)$ to obtain the correct model as in Equation (2.37).

In spite of the authors' note that the time-dependent function is not based on any realistic queueing analysis, recent theoretical and simulation work reported in the literature indicates that the time-dependent form is realistic.

Note that the form of the delay equation used in Australia (Akçelik, 1990) has capacity per cycle (product of saturation flow and green time) as an extra parameter, predicting less delay for a movement which has a higher capacity per cycle (major route) under the same degree of saturation. This has important implications in terms of the relative delays on major and minor routes, an issue to which the authors devote a great deal of attention. The authors should also note a recent paper by the reviewer that discusses cost functions including the time-dependent equivalent of Davidson's function and proposes an alternative time-dependent function (Akçelik, 1991).

An important weakness of Webster's delay model is the assumption of isolated signal operation. Simple delay models that allow for platooned arrivals by using progression factors as in the Highway Capacity Manual could be used for more realistic analysis of traffic in urban areas, although further development is needed in this area.

There are other serious shortcomings in the modelling of networks which should be improved in future studies. Among these, the most serious shortcoming is the lack of allowance for capacity losses due to the existence of downstream queues (queue interaction) and the resulting backward spread of congestion (Johnson & Akçelik, 1992; Rouphail & Akçelik, 1992). Another issue is that the random/overflow delays appear to be over-predicted by existing coordinated signal models (Akçelik & Rouphail, 1993). These are very relevant to network modelling in the context of demand management and route guidance.

More attention should also be paid to the variable-demand issue for correct modelling in relation to the study of the combined traffic assignment and control problem in an equilibrium context as the authors have adopted.

In dealing with the traffic assignment methods, the authors consider the classical user-optimal and system-optimal assignment principles, actual versus perceived costs, and multiple user classes. These are all relevant in the context of route guidance. Travel time (considered to represent travel cost) is used as the route choice criterion. This represents a weakness in assignment as seen in the simple, but useful, two-route example used in Chapter 3 by the authors to highlight various issues.

In fact, the simple two-route example indicates the shortcoming of the use of travel time as the route choice criterion. In many cases, using this criterion, all flows are assigned to the minor route. Serious consideration should be given to the use of the number of stops combined with delay (travel time) to represent the travel cost. As used in most models for traffic design, the number of stops is important in accurate prediction of operating costs (fuel consumption, etc). The minimum-delay and minimum-stop solutions diverge particularly in terms of the optimum cycle time and optimum major-minor route green splits. In terms of route choice, the number of stops would represent driving quality and could explain why the drivers would choose a freeway-type facility against a road through a town center (with many intersections) even if the travel time is somewhat longer.

In Chapter 5, more realistic findings are obtained from the analysis of real-life networks, which show that the minimum-delay policy performs best in terms of resulting network travel times.

Chapter 7 presents the results of route guidance tests by simulating two networks using a multiple user class assignment model. The main finding is that there are additional benefits from the integration of route guidance with traffic control, compared to the benefits from route guidance alone. However, the authors rightly emphasize that such tentative conclusions need to be verified by further tests on a multitude of networks and with different model assumptions.

In the concluding chapter, the authors make a strong case for the use of an iterative assignment control procedure, challenging theoreticians who have criticized this method as a rather poor heuristic. They argue that no efficient solution methods currently exist for the network design problem, and that proposed alterative solution methods are either very cumbersome or they depend on extreme simplifications in the network description and/or the cost assumptions to enable convenient mathematical approaches. The authors question the validity and actual value of any resulting optimum green splits that result from such calculations. In this, the authors have the full support of the reviewer!

Van Vuren and Van Vliet's work is a valuable contribution to the study of the combined traffic assignment and control problem. They have set the stage; but substantial analytical work will be required before reliable models are developed for the purposes of demand management, network design, and dynamic route guidance. Analytical work should continue along the same lines until some significant modelling issues are resolved.

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RAHMI AKÇELIK
Australian Road Research Board Ltd.
P.O. Box 156
Nunawading, Victoria 3131, Australia