In alphabetical order, with abstracts

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Abdelghany KF, Mahmassani HS (2001) Dynamic trip assignment-simulation model for intermodal
transportation networks. Transportation-Research-Board 1771: Transportation Network Modeling - Planning
And Administration, 52-60.
AB A dynamic trip assignment-simulation model for urban intermodal transportation networks is presented.
The model considers different travel modes, such as private cars, buses, metro-subway, and high-occupancy
vehicles. The model captures the interaction between mode choice and traffic assignment under different
information provision strategies. It implements a multiobjective assignment procedure in which travelers
choose their modes and routes based on a range of evaluation criteria. The model assumes a stochastically
diverse set of travelers in terms of their relevant choice criteria and access and response to the supplied
information. The model overcomes many of the known limitations of static tools used in current practice. These
limitations relate to the types of alternative measures that may be presented and evaluated and to the policy
questions that planning agencies are increasingly asked to address.

Abdelghany, AF, Mahmassani, HS, Chiu, YC (2001) Spatial microassignment of travel demand with activity trip
chains. Transportation Research Record 1777, 36-46.
AB As activity-based approaches gain acceptance for travel demand analysis and forecasting in practice, the unit
of analysis in transportation planning models needs to shift from a one-way trip to an activity schedule with
associated trip chains. A spatial network assignment process and its application to an actual network are
described; the process can be used in conjunction with activity-based travel demand forecasting procedures as
well as for traffic operational studies. Two simulation-based dynamic spatial microassignment procedures for
travel demand with activity trip chains are presented. The first represents a one-step simulation-assignment
procedure in which assignment of trips is based on prevailing travel time. The second is an iterative simulation-
assignment procedure in which a user equilibrium solution is obtained. The models are illustrated through various
experiments conducted using an actual network (in Fort Worth, Texas) to examine network performance under
different activity and trip-chaining scenarios. Different demand levels with different trip chain patterns are
considered and compared for an actual transportation network. In addition, a case is made for dynamic
microassignment of activity trip chains by contrasting it with current practice and illustrating the pitfalls of
inappropriately recognizing trip chains using current-practice assignment. In particular, two different procedures
are considered and compared for selected test scenarios with the dynamic assignment models presented. The first
procedure corresponds to the case in which the activity and trip-chaining behavior is completely ignored, and
only the final destination in the chain is considered. The second procedure treats the links of the chains separately
as independent trips, without appropriate linkage between them.

AB Application of a dynamic traffic assignment-simulation methodology to the analysis and evaluation of network performance under various schemes for the design and operation of high-occupancy toll (HOT) lanes is described. The DYNASMART traffic simulation-assignment model, which combines the ability to simulate traffic flow and to represent dynamic route choice behavior, is used to model the problem. Different dimensions for the design and operation of HOT lanes are considered in this study, including (a) lane utilization in terms of adding a new lane or using an existing lane of the facility as a HOT lane; (b) physical separation of the HOT lane in terms of access point frequency; (c) access restriction based on vehicle occupancy; (d) HOT lane pricing structure, which may be fixed or congestion dependent; and (e) different demand levels with different percentages of high-occupancy vehicles (HOV). A set of experiments was designed to compare the performance of the HOT lanes and the total network under these different operating characteristics. A network in Texas that represents the south central part of the Fort Worth area is used in these experiments. The results were analyzed under each of these different operating characteristics, yielding useful insights for the design and evaluation of HOT lanes.


AB As an example of integrating signal control with network traffic assignment, the notion of path-based signal coordination in transportation networks is introduced and illustrated. The use of a real-time dynamic traffic assignment system allows prediction of the traffic flow patterns and identification of the dominant paths in the network. The signalized intersections along these paths, which may consist of combinations of straight sections and turning movements, are coordinated to increase the capacity of the freeway and the surface street system to efficiently absorb diverted traffic from the freeway. A set of experiments is designed to compare the network performance under the path-based coordination scheme with no coordination and arterial-based coordination. The experiments are conducted for both pretimed and vehicle-actuated signal control. An actual network, which represents the south-central part of the Fort Worth area, is used in these experiments. The network consists of a freeway (I-35W) surrounded by a street network with a total of 178 nodes and 441 arcs. The path-based coordination scheme is shown to outperform arterial-based coordination in the cases of both pretimed fixed control and vehicle-actuated signal control. A significant reduction in the network average travel time under the path-based coordination scheme is observed compared with the other schemes. This application further illustrates the benefits of real-time dynamic traffic assignment for advanced traffic management under incident conditions.


AB Optimization of system performance in congested traffic networks is one of the main goals of intelligent transportation systems. A formulation and solution algorithm for the combined signal control and dynamic traffic assignment problem is presented. The solution algorithm is implemented and tested on an actual network, illustrating the benefits that could be attained through joint optimization of signal control and route guidance decisions.


AB This paper investigates the temporal inflow profile that minimises the total cost of travel for a single route. The problem is formulated to consider the case in which the total demand to be serviced is fixed. The approach used here is a direct calculation of the first order variation of total system cost with respect to variations in the inflow profile. Two traffic models are considered; the bottleneck with deterministic queue and
the kinematic wave model. For the bottleneck model a known solution is recovered. The wave model proves more difficult and after eliminating the possibility of a smooth inflow profile the restricted case of constant inflow is solved. As the space of possible profiles is finite dimensional in this case, the standard techniques of calculus apply. We establish a pair of equations that are satisfied simultaneously by the optimal inflow and time of first departure.


AB Creation of a new link or increase in capacity of an existing link can reduce the efficiency of a congested network as measured by the total travel cost. This phenomenon, of which an extreme example is given by Braess paradox, has been examined in conventional studies within the framework of static assignment. For dynamic traffic assignment, which makes account of the effect of congestion through explicit representation of queues, Akamatsu (2000) gave a simple example of the occurrence of this paradox. The present paper extends that result to a more general network. We first present a necessary and sufficient condition for the paradox to occur in a general network in which there is a queue on each link. We then give a graph-theoretic interpretation of the condition, which gives us a convenient method to test whether or not the paradox will occur by performing certain tests on information that describes the network structure. Finally, as an application of this theory, we examine several example networks and queueing patterns where occurrence of this paradox is inevitable. (Does this kind of results depend on link performance models used and/or DTA models employed? How were links modelled, two segments: cruising and queueing?)


AB This paper presents an efficient algorithm for solving the dynamic user equilibrium (DUE) traffic assignment with a one-to-many origin-destination (OD) pattern. To achieve the efficiency of the algorithm, we employ the following three strategies. First, we exploit the decomposition property of the DUE assignment with respect to the departure time from an origin; we consider the algorithm that solves each of the decomposed DUE assignments sequentially. Second, we represent the decomposed DUE assignment by an arc-node formulation, not by using path variables. Third, we take advantage of the fact that the decomposed DUE assignment reduces to (finite dimensional) nonlinear complementarity problems (NCPs); we develop the algorithm based on the globally convergent Newton's method for general NCPs. These strategies, together with graph theoretic devices, enable us to design a new algorithm which does not require path, enumeration and is capable of dealing with very large-scale networks. Numerical experiments disclose that the proposed algorithm solves the DUE assignment very rapidly, even in large-scale networks with some thousands of links and nodes where conventional heuristic algorithms do not converge to the accurate equilibrium solution.


AB This paper explores the properties of dynamic flow patterns on two symmetrical networks: an "evening-rush-hour" network (E-net) with a one-to-many origin-destination (OD) pattern and a "morning-rush; hour" network (M-net) with a many-to-one OD pattern that can be obtained by reversing the direction of links and the origin and destinations of the evening-rush-hour network. Although conventional static traffic assignment produces exactly the same flow pattern for both networks, such a simple result does not hold for dynamic assignment. We show this result theoretically by using dynamic equilibrium assignment with a point queue model. Specifically, we first derive the closed form solutions of the dynamic assignment for both networks. We then identify the essential differences between the two dynamic network flow patterns by comparing the mathematical structure of the solutions. Furthermore, a type of capacity paradox (a dynamic version of Braess's paradox [Braess, D., 1968, Uber ein paradox in der verkehrsplanung. Unternehmensforschung, 12, 258-268.]) is identified in order to demonstrate the differences.

Major requirements for operationalization of the concept of sustainable development in urban transportation infrastructure operations management are presented. In addition, it is shown that the current approach to management is incompatible with the requirements for sustainable urban development. Consequently, the conceptual framework of a desirable approach is proposed. The philosophy of this approach is that the basic mission of infrastructure operations management is to obtain and maintain the maximum levels of people and goods mobility possible within the resources and environmental capacities in an area. A mathematical model is presented for obtaining the desirable levels and characteristics of traffic on each segment of an urban transportation network. In addition, three illustrative applications of the implemented model are presented. (Is a DTA model used?)


Two algorithms are presented for assigning time-varying traffic demand to a road network during peak period. The algorithms are heuristics based on the principle of deterministic equilibrium, and they are iterative. Discrete time approach is adopted for computational simplicity. The model presented is suitable for simulating traffic flow in a road network during peak period in urban areas for strategic planning of transport systems.


We consider a noncooperative game framework for combined routing and flow control in a network of parallel links, where the number of users (players) is arbitrarily large. The utility function of each user is related to the power criterion, and is taken as the ratio of some positive power of the total throughput of that user to the average delay seen by the user. The utility function is nonconcave in the flow rates of the user, for which we introduce a scaling to make it well defined as the number of users, N, becomes arbitrarily large. In spite of the lack of concavity, we obtain explicit expressions for the flow rates of the users and their associated routing decisions, which are in O(1/N) Nash equilibrium. This O(1/N) equilibrium solution, which is symmetric across different users and could be multiple in some cases, exhibits a delay-equalizing feature among the links which carry positive flow. The paper also provides the complete optimal solution to the single-user case, and includes several numerical examples to illustrate different features of the solutions in the single-as well as N-user cases, as N becomes arbitrarily large.


D. Braess and others have shown that creating a new link in a congested network, or adding capacity to an existing link, can raise total travel costs if drivers switch routes. Here we show that a paradox can also result..
when routes are fixed, but users choose when to travel. As is true of the Braess paradox, the paradox here arises when the inefficiency due to underpricing of congestion increases by more than the direct benefit of the new capacity. For a corridor with two groups of drivers, we show that expanding capacity of an upstream bottleneck raises travel costs when the reduction in congestion upstream is more than offset by increased congestion downstream. Metering can thus improve efficiency. Optimal capacity for an upstream bottleneck is equal to, or smaller than, optimal capacity downstream. Total construction costs equal total variable travel costs when capacities are optimal and construction costs are independent of scale.


Most theoretical studies of traffic congestion during the morning commute have been limited to one origin, one destination, and one route. This paper is the first to analyze systematically user equilibrium, system optimum, and various pricing regimes for a simple network of routes in parallel. Departure time and route decisions of commuters are assumed to be governed by the tradeoff between travel time and schedule delay (the difference between actual and desired arrival time). In equilibrium without tolls wasteful queuing occurs, although the numbers of drivers on each route is the same as in the system optimum. An optimal time-varying toll eliminates queuing without affecting route usage. Uniform and step tolls alter route usage, but only slightly. Step tolls generally yield much greater efficiency gains than uniform tolls because they reduce queuing by altering departure times.


After introducing a classification of dynamic network loading (DNL) procedures (based on time, space, and demand discretization), many new methodologies recently presented are discussed. Some analytical properties of the point packet approach, recently studied by Chabini and Kachani [1], using generalized Dirac functions, are discussed, and results are extrapolated to the proposed procedure (called MICE [2]). The connection between the dynamic network loading procedure MICE and the analytical formulation presented in (3) is explained. The same demand discretization is suggested in the solution of all analytical traffic flow models.


Interest in temporal modeling of road traffic has increased over the past decade because of the need to model traffic dynamics for the purpose of evaluating a variety of intelligent transportation components, such as traffic control measures and route guidance. Several approaches are available, including macroscopic, mesoscopic, and microscopic traffic models as well as analytical dynamic assignment models. Although microscopic models are the most detailed and realistic, they are difficult to calibrate and may not be the most practical tools for large-scale networks. Three methods for dynamic network loading that are considerably less detailed than microscopic modeling are investigated here. Each of the three methods is based on a different approach to modeling traffic dynamics: link-based travel time functions, the cell-transmission model, and a link-based model derived from a simplified car-following relationship. A small test network was devised, and the results from each model were compared with those obtained from a microsimulator (INTEGRATION). Interpretation of the discrepancies observed in the results gave an indication of the relative importance of the different components of the three traffic models.

A time-dependent network assignment strategy is proposed for efficiently handling aircraft taxiway operations at airports. The suggested strategy is based on the incremental assignment technique that is frequently adopted in many urban transportation studies. The method assumes that the current aircraft route is influenced by previous recent aircraft assignments in the network. This simplified assumption obviates the need for iterative rerouting procedures for attaining some pure equilibrium state, which in any case might not be achievable in practical airport taxiway operations. The main benefit of applying the time-dependent network assignment approach to taxiway operations is the reduction and avoidance of possible conflicts that produce delays. Also proposed is a prototype of a fully time-dependent network assignment scheme that dispatches aircraft based also on future anticipated assignment. The suggested methodology could be adopted in the deployment of automated taxiway guidance systems that are planned for future implementation at congested airports.


An optimal control algorithm for solving dynamic, nonlinear, discrete time, linearly constrained optimization problems based on feasible direction search and the reduced gradient is applied to integrated optimal flow control in single destination traffic networks with time-varying demand flows. A numerical example is presented to demonstrate the feasibility of the approach. The results of this work, especially concerning required computation time and demand flows assumptions, are relevant for real-time implementation of the algorithm.


Signalized urban areas are considered in order to improve the performances of traffic systems by means of real-time actions having the purpose of varying the length of traffic lights phases with respect to pre-defined durations. In this connection, a macroscopic traffic model and an optimization problem are presented in this paper. The proposed model allows the representation of all possible traffic conditions (congested as well as non-congested). The optimization problem is stated with the objective of minimizing the number of vehicles in the overall system, over the whole optimization horizon, by suitably choosing the duration of the phases in each semaphoric cycle.


This review reports the existing literature on traffic flow modelling in the framework of a critical overview which aims to indicate research perspectives. The contents mainly refer to modelling by fluid dynamic and kinetic equations and are arranged in three parts. The first part refers to methodological aspects of mathematical modelling and to the interpretation of experimental results. The second part is devoted to modelling and deals both with methodological aspects and with the description of some specific models. The third part reports about an overview on applications and research perspectives.


This paper reviews key aspects of route guidance and information systems (RGISs), which disseminate to drivers messages with information and recommendations intended to assist their route choice decisions. It first
summarizes the major features that characterize and distinguish different RGIS designs. An important distinction exists between non-predictive and predictive systems. In the former, guidance messages are based on measurements or estimates of prevailing network conditions, while, in the latter, messages are derived from forecasts of future conditions. For predictive systems, the key issue is consistency: ensuring that drivers' reactions to guidance derived from forecasts do not invalidate those forecasts. It is shown that the determination of consistent guidance must be model based and can be formulated as a fixed-point problem. The modelling of driver response to guidance is a relatively new subject; the paper surveys the main issues, and relates these to the user- and system-level evaluation of RGISs. A final section identifies some areas of current research.

AB Successful operation of Advanced Traffic Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS) requires a dynamic traffic model that can operate in real time and reliably predict traffic congestion. We present a dynamic traffic model system that consists of four modules: surveillance, origin-destination, congestion prediction and control strategy generation. The heart of the system is a flexible traffic simulation model. A prototype implementation of the proposed system is briefly described.

AB In recent years new insights and algorithms have been obtained for the classical, deterministic vehicle routing problem as well as for natural stochastic and dynamic variations of it. These new developments are based on theoretical analysis, combine probabilistic and combinatorial modeling, and lead to new algorithms that produce near-optimal solutions, and a deeper understanding of uncertainty issues in vehicle routing. In this paper, we survey these new developments with an emphasis on the insights gained and on the algorithms proposed.

AB We propose a measure of quality for OD trip tables estimated from link counts. This measure, called the total demand scale is based only on the estimated OD trip table and on the assignment matrix used to estimate it. It is independent of the OD estimation method and of the technique used to overcome the underdetermination of the OD estimation problem. The total demand scale measures the intrinsic underdetermination related to the OD estimation problem, considering only the network topology and the underlying route choice model. Because it identifies the level of arbitrariness introduced by the a priori matrix in the estimation process, our approach helps to evaluate if an important amount of resources must be invested for the a priori matrix, or if the available link counts contains sufficient information. The computation of the total demand scale enables to identify at zero additional cost those OD pairs such that no measurement is available on any path linking them. A MATLAB code for the computation of the total demand scale is also provided.

AB This paper presents a method for finding optimal flows in a dynamic network with random inputs into the system and congestion limits on flow. This model has been used in deterministic settings to represent dynamic traffic assignment and job shop routing. This paper builds on the deterministic results to show that a globally optimal solution in the stochastic problem may be obtained by a sequence of linear optimizations. A decomposition algorithm for this procedure is presented that efficiently solves problems with large-scale deterministic equivalents of up to 66,000 variables.

AB Multistage stochastic linear programs model problems in financial planning, dynamic traffic assignment, economic policy analysis, and many other applications. Equivalent representations of such problems as deterministic linear programs are, however, excessively large. This paper develops decomposition and partitioning methods for solving these problems and reports on computational results on a set of practical test problems.


AB We consider the extension of a single user-class macroscopic dynamic traffic assignment model to include multiple user-classes. The distinction between user-classes is typically based on vehicle characteristics, e.g. cars and trucks. Interactions between the user-classes sharing the same road infrastructure are taken into account. To deal with various different asymmetries that may occur, such as interuser-class interaction, interspatial and intertemporal asymmetries, the model is specified as a (quasi) variational inequality problem. A nested modified projection method is proposed to solve the assignment problem. The solution of the problem depends heavily on the choice of some very important input: the multiclass link travel time functions. Under mild restrictions there exists a solution, which need not be unique. A case study illustrates the model.


AB The extension of a single-user-class macroscopic dynamic traffic assignment model to include multiple user classes is considered. The distinction between user classes is based on vehicle characteristics. Cars and trucks are two typical classes. To deal with various asymmetries that may occur, such as intra-user-class interaction and spatial and temporal asymmetries, the model is specified as a quasi-variational inequality problem. A nested modified projection method is successfully adopted to solve the assignment problem. The solution of the problem depends heavily on the choice of some very important input: the multiclass link travel time functions. Under mild restrictions there exists a solution, which need not be unique. A case study illustrates the model.


AB We consider a network shared by noncooperative two types of users, group users and individual users. Each user of the first type has a significant impact on the load of the network, whereas a user of the second type does not. Both group users as well as individual users choose their routes so as to minimize their costs. We further consider the case that the users may have side constraints. We study the concept of mixed equilibrium (mixing of Nash equilibrium and Wardrop equilibrium). We establish its existence and some conditions for its uniqueness. Then, we apply the mixed equilibrium to a parallel links network and to a case of load balancing.


AB Dynamic traffic assignment (DTA) has been a topic of substantial research during the past decade and the DTA models offer the potential to support effective evaluation and operation Advanced Transportation Management System (ATMS) and Advanced Transportation Information System (ATIS). But still, many aspects of DTA need improvement, especially its behavior assumptions. In a realistic setting, one might expect that network travel times at each time for given traffic flows are stochastic in nature. The model presented in this paper is a stochastic dynamic user optimal model based on a stochastic dynamic network. The assumption is that route travel times are variable and perceived as such by travelers at each time instant. Route choices are
assumed to be made with the objective of minimizing perceived disutilities at each time. These perceived
disutilities depend on the distribution of the variable route travel times, the distribution of individual perception
errors and the individual traveler's risk taking nature at each time. The route choice criterion in this model is the
traveler's perceived disutility. The form of the disutility function is dependent on the behavioral assumptions
made about the traveler. The assumptions about the behavioral nature of travelers are that they are either risk
averse, risk prone or risk neutral. Three different disutility functions for risk averse, risk prone and risk neutral
behavior types will be used in this study. The risk-taking behavior will be integrated into the model through a
Variational Inequality approach. Subsequently, we will discuss a solution algorithm for the VI. This algorithm
uses a combination of various solution techniques, such as relaxation and Method of Successive
Averages(MSA). It will be applied to several scenarios to verify the correctness of the solutions obtained
and demonstrate the property of risk-taking behavior model in the context of dynamic route choice.

AB Application and extensions of a dynamic network equilibrium model to the Advanced Driver and Vehicle
Advisory Navigation Concept (ADVANCE) Network are described in this paper, ADVANCE is a dynamic
route guidance field test designed for 800 km(2) in the northwestern suburbs of Chicago. The dynamic route
choice model employed in this paper is solved efficiently by a modified version of Janson's DYMOD
algorithm. Realistic traffic engineering-based link delay functions, instead of the simplistic Bureau of Public
Roads (BPR) function, are used to estimate link travel times and intersection delays for most types of links and
intersections. Further, an expanded intersection representation is utilized, resulting in a network of nearly
23,000 links and 10,000 nodes. Time-dependent link flows, travel times, speeds and queue spillbacks are
generated for the ADVANCE Network. Convergence and computational results are presented and analyzed.

Transportation Science 29, 128-142.
AB Dynamic models of the behavior of automobile drivers in choosing routes through urban transportation
networks are required for the design and operation of intelligent transportation systems generally, and traveler
information systems in particular. In this paper, drivers' route choice behavior based on current, or
instantaneous, information on network conditions is described using an optimal control theory formulation. The
time-dependent origin-destination vehicle trip pattern is assumed to be known. The instantaneous dynamic
user-optimal route choice problem is to allocate vehicle flows to the current minimal-cost routes, defined as the
routes that minimize the route travel cost between each decision node (any node on the route including the
origin) and the destination node based on the currently prevailing travel times. The continuous time formulation
of the problem is transformed into a discrete time nonlinear programming (NLP) formulation. Each of a
sequence of NLPs is then solved by an algorithm based on the Frank-Wolfe technique. In this sequence,
approximate link travel times are updated iteratively in order to represent flow propagation over routes.
Computational results from applying the algorithm to two test networks conclude the paper.

Transportation Networks: Recent Methodological Advances, Bell MGH (ed), 303-317.
AB Travel time is the commonly used cost function for dynamic road traffic assignment. The paper begins
with a review of various travel time and aggregation methods used in simulation models. It further attempts to
clarify the different definitions of travel times given in the literature: experienced travel time, predictive travel
time, instantaneous travel time and to give mathematical definitions of these quantities, notably for
macroscopic models. Finally recursive computational procedures are given for the discretized case.

Camynta-Baezie, G, Cassir, C, Bell, M (1999) Multi-user class pseudo-dynamic traffic assignment model with
signal control. IEEE AFRICON Conference, v 1, 37-42.
A multi-user class pseudo-dynamic traffic assignment model is presented. It combines deterministic and stochastic user-equilibrium route choice models and defines two classes of drivers; the guided drivers and the unguided drivers. Three signal policies are introduced into the model and the effect of these policies on drivers are presented.


Traditionally, traffic assignment models, both for within-day static and dynamic demand, have been formulated following an equilibrium approach in which a state ensuring internal consistency between demand (flows) and costs is sought. However, equilibrium analysis is significant under some assumptions on its "representativeness" (coincidence or closeness with the actual attractor of the system) and analytical properties, such as existence, uniqueness, and stability. Moreover, transients due to modifications of demand and/or supply cannot be simulated through equilibrium models, nor can a statistical description of the state of the system, i.e. means, modes, moments and, more generally, frequency distributions of flows over time be obtained. In this paper, interperiodic (day-to-day) dynamic modeling of transportation networks is addressed following two different approaches, namely deterministic and stochastic processes; In both cases several theoretical results are shown by making use of a formal framework covering most models discussed in the literature as well as some possible extensions. Most of the results reported can be extended to cover within-day dynamic models but these models are not explicitly dealt with. Within the framework of deterministic processes the relevance of day-to-day dynamic models for demand/supply interaction in comparison with the traditional user equilibrium approach is discussed, and conditions for coincidence of fixed-point attractors and equilibrium states are stated. Conditions for existence and uniqueness of fixed-point attractors are proposed, generalizing and extending those presented in the literature for user equilibrium. Conditions for stability of both fixed-points and equilibrium states were formulated by making use of results from non-linear dynamic system theory. Moreover, it is possible to devise a new family of “dynamic” algorithms which simulate the system convergence to a fixed-point in order to obtain. art equivalent equilibrium state, as opposed to conventional "optimisation" algorithms. In this case the fixed-point stability analysis can be viewed as a convergence analysis for the algorithms specified this way. Conditions for stochastic process regularity are proposed ensuring, among other things, existence and uniqueness of a stationary probability distribution of system states. These conditions generalize and extend results presented in the literature to a wider class of possible dynamic models. Relationships between a deterministic process, together with corresponding fixed-points or equilibrium states, and stochastic probability distribution are also briefly addressed. Finally, some numerical examples confirming theoretical results are reported for a small test network.


In a model commonly used in dynamic traffic assignment the link travel time for a vehicle entering a link at time t is taken as a function of the number of vehicles on the link at time t. In an alternative recently introduced model, the travel time for a vehicle entering a link at time t is taken as a function of an estimate of the flow in the immediate neighbourhood of the vehicle, averaged over the time the vehicle is traversing the link. Here we compare the solutions obtained from these two models when applied to various inflow profiles. We also divide the link into segments, apply each model sequentially to the segments and again compare the results. As the number of segments is increased, the discretisation refined to the continuous limit, the solutions from the two models converge to the same solution, which is the solution of the Lighthill, Whitham, Richards (LWR) model for traffic flow. We illustrate the results for different travel time functions and patterns of inflows to the link. In the numerical examples the solutions from the second of the two models are closer to the limit solutions. We also show that the models converge even when the link segments are not homogeneous, and introduce a correction scheme in the second model to compensate for an approximation error, hence improving the approximation to the LWR model.

In network models for dynamic traffic assignment the link travel times are often described by "whole-link" models. In particular, they have been expressed as a function of the number of vehicles currently on the link. Such whole-link models are useful approximations and make the network model tractable when flows and travel times are varying over time. Here we propose an alternative whole-link model to approximate travel times. For a vehicle entering a link at time $t$, we let the link travel time be a function of a weighted average of the inflow rate at the time it enters and the outflow rate at the time it exits. We show that this model ensures FIFO and has other desirable properties. We indicate computational methods for solving the model, apply it to various patterns of inflows, and compare the numerical results with two alternative whole-link models.


Whole-link models of traffic flows have been widely used in mathematical programming models for dynamic traffic assignment (DTA). In this paper, we consider a well-known whole-link model in which the link travel time, for traffic entering at time $t$, is a function of the number of vehicles on the link, and may also be a function of the inflow rate or outflow rate at time $t$. Instead of considering this in a network context, we examine its behaviour for a single link, for given inflow profiles, so as to distinguish behaviour within a link from network behaviour. We consider steady state solutions, for constant inflows and outflows, note that various model forms can yield the same solution, and that under certain conditions the model may admit multiple values for the link travel time. We derive the complete analytic solution for a model where the travel time depends linearly only on the number of vehicles on the link, and show that the solution exhibits pseudo-periodicity, and converges to a steady state solution. The results indicate that the analytic solution is quite complex even for very simple cases, and that care has to be exercised in the choice of parameters. We illustrate the solutions numerically.


In mathematical programming models of time-varying flows on traffic networks (dynamic traffic assignment) a key component is the model of flow behaviour within individual links. However, to maintain tractability in these models, time-varying link flows tend to be modelled in very simple ways. Here we try to model link flows more flexibly, so that the trip time of a vehicle on a link is influenced by the flow rate when the vehicle enters the link, the how rate when the vehicle exits from the link, and knock-on effects from traffic ahead on the link. We concentrate on congestion along links, but the model can be extended, for example by dividing each link into a travel link followed by a queue 'link'. We also concentrate on a system optimising model but outline how this can be extended to user equilibrium. We consider the properties of the model, and find that the first-in-first-out (FIFO) property of road traffic holds unless there is a sharp increase in inflows to a link followed by a sharp decrease. We also investigate the "holding back" of flows, a phenomenon associated with intertemporal network optimisation models in general. We apply the model to simple network examples, The model has the advantage of being linear and having a special structure which may be exploited to develop more efficient solution techniques.


In modeling flows and controls in transportation, distribution, communication, manufacturing systems, etc., it is often convenient to represent the system as a store-and-forward network. In such networks it is common for time, space, attention, or other resources, to be shared between sets of neighbouring nodes. For example, neighbouring nodes may share storage space, machine time, operating time, etc. The allocation of this shared resource among nodes determines a set of `controls' on the network arc flows. We develop a multi-period network model which describes such storage and forwarding, and the sharing of resources (controls) between subsets of nodes. To solve the model we develop algorithms which take advantage of the embedded network structure of the problem. Each of the algorithms is based on iterating between (a) solving a least-cost capacitated network flow problem with fixed capacities (controls) and (b) solving a set of simple small scale
problems to update these controls. In a series of computational experiments we found that an ('unoptimized') implementation of the algorithms performed between 13 and 42 times faster than a good linear programming code, which is the natural alternative. Also, by decomposing the problem, the algorithms make solving larger scale problems tractable, and are suitable for implementation on parallel processors.


AB For congested networks on which flows vary over time, we derive system marginal costs, user perceived costs and user externality costs, for each arc and path. We also obtain a set of optimal congestion tolls and flow controls which may be used to shift the user determined flows toward a socially preferred pattern. An important way in which our results differ from the usual static analysis is that the social cost externality depends not only on the level of congestion, but also on the rate of increase or decrease of congestion. This is intuitively explicable as follows. Consider users delayed on an arc. Their delays will be further compounded or multiplied if congestion has increased during the time they are delayed. On the other hand, their delays will be reduced if congestion has declined during the time they are delayed. This multiplier effect is such that the resultant dynamic externalities can easily be a few times larger, or smaller, than the externalities derived in the usual static analysis. As a result, the congestion tolls or tariffs which are usually proposed or advocated, based on static analysis, may be inappropriate. The results are illustrated with a numerical application to a small network example.


AB We identify and discuss what appears to be a central difficulty for the future development of models of dynamic traffic flows on road networks. This difficulty is due to the fact that road traffic tends to behave in a first-in-first-out (FIFO) manner: that is, traffic which embarks on a road or other facility in period t exits from that facility ("on average") before traffic which enters in any later time periods. The FIFO requirement does not cause a problem in static traffic assignment, but we show that it yields a nonconvex constraint set in dynamic assignment, especially if there are multiple destinations or commodities. We consider various formulations, each of which yields a nonconvex optimization problem which is at present computationally tractable only for relatively small-scale examples. The above FIFO problem arises even if there is no congestion, and even if travel demands are fixed. Further the problem arises whether we are modeling a system optimum or a user equilibrium, and whether we use an optimization formulation or a complementarity or variational inequality formulation. We make some suggestions for dealing with, or avoiding, the problem and for further research.


AB We are concerned with variation over a peak period, and for application we focus on modeling the morning rush-hour (the journey to work). We treat this as a multiple-origin, single-destination network model, the destination being the central business district. We use a system optimizing model, and allow the travel demands to vary with the cost (or price) of making a trip. The tradeoff between travel time and the cost of being early or late is considered for different work-start time policies, such as fixed work-start time and flex-time. For illustration, we apply the model to a simple network example and compare the congestion patterns and travel costs under each policy.


AB We present a general framework for the simulation of dynamics in transportation networks. Models and algorithms for both within-day and day-to-day dynamic traffic assignment are discussed. The proposed framework includes static models as a particular case, and is general enough to cover most of the existing models.


AB This paper proposes different 'dynamic' estimators using time-varying traffic counts to obtain (discrete) time-varying OD flows or average OD flows. All the estimators can combine counts with other available information, e.g., out-dated matrices and surveys, on a general network and can be formulated as optimization problems. In the case of time-varying OD flows, two types of estimators are proposed. Simultaneous estimators produce joint estimators of the whole set of OD matrices, one for each time slice, whereas sequential estimators produce a sequence of OD estimates for successive time slices. A particular type of simultaneous and sequential estimator (namely Generalized Least Squares) was tested on the Italian Bressica-Padua motorway for which 'true' OD flows over a whole day were available. Results were generally satisfactory, showing that also in the 'no a priori information' case significant estimates could be obtained.


AB In this article a doubly dynamic assignment model for a general network is presented. It is assumed that users' choices are based on information about travel times and generalized transportation costs occurred in a finite number of previous days and, possibly, in previous periods of the same day. The information may be supplied and managed by an informative system. In this context, path and link flows vary for different subperiods of the same day (within-day dynamics) and for different days (day-to-day dynamics). The proposed model follows a nonequilibrium approach in which both within-day and day-to-day flow fluctuations are modelled as a stochastic process. A model of dynamic network loading for computing within-day variable arc flows from path flows is also presented. The model deals explicitly with queuing at oversaturated intersections and can be formulated as a fixed point problem. A solution scheme for the doubly dynamic assignment model is presented embedding a solution algorithm for the fixed-point problem.


AB The dynamic network loading problem is considered. This problem is at the heart of analytical approaches to dynamic traffic assignment models. Given path flow rate and link travel time functions, the dynamic network loading problem consists of determining time-dependent network flow conditions, such as link travel times, total number of vehicles on links, and link inflow and outflow rates. The dynamic network loading problem is formulated as a continuous-time system of nonlinear equations expressing link dynamics, flow conservation, flow propagation, and boundary constraints. A discrete-time version of the continuous-time model is developed to design solution algorithms. Two solution algorithms are developed and implemented efficiently. Techniques are described that were designed to reduce memory usage and computation times of these solution algorithms. Computational results with a real-world traffic network emanating from the Amsterdam A10 beltway, containing 300 nodes, 1,500 paths, 1,000 origin-destination pairs, and 2 h of analysis...
period indicate that the developed computer implementations can solve the network loading problem in 2 min when a small discretization interval of 3.5 s is used.

AB This paper presents an integrated method for estimating time-varying O-Ds in urban networks. The proposed method starts with our previously developed two-stage, non-assignment-based model that can yield a time-varying O-Ds without a reliable prior O-D set and a dynamic traffic assignment model (DTA). With the initial estimated O-D set, one can compute the link-incident matrix with any acceptable DTA model and generate a revised distribution of network O-Ds. To further improve the estimation accuracy and also account for the impact of urban signals, we have developed an intersection O-D estimation model that can produce an additional set of system observation constraints based on either existing or estimated intersection turning fractions. Although the statistical properties and variances of such a system under a large-scale network remain to be investigated, the results of simulation experiments have clearly indicated that our proposed method for integrated estimation of time-varying network O-D distributions is quite promising. (C) 1999 Elsevier Science Ltd. All rights reserved.

AB Existing studies for network O-D estimation from link counts remain exploratory in nature, mostly developed on the assumption of having reliable prior O-D matrices and an accurate dynamic traffic assignment model. The computational requirements for use in large-scale networks have never been addressed either. This research presents a mathematical model and its computing architecture that allow for real-time estimation of dynamic O-D matrices in large-scale networks. The proposed model employs only link flow counts and dynamic screenline flows, and makes no assumption on drivers' route choice behavior. For a large network, the proposed model attacks the complex estimation issue in two stages: decomposing the entire network into several subnetworks for parallel computing in the first stage, followed by the update of key parameters with specially-designed screenline flows in the second stage. The preliminary results have shown the promising properties of the proposed method.

AB This research presents a dynamic system model and its on-line estimation algorithm for time-varying freeway origin-destination (O-D) matrices. The proposed model employs information from mainline traffic counts, ramp flow measurements, and macroscopic traffic characteristics to construct a set of dynamic
equations, which realistically consider the interrelations between O-D distributions and observed flows under congested conditions. To improve the operational efficiency necessary for real-time applications, a revised model with some approximation have also been developed. Due to the difficulty in acquiring the real-world data, the proposed model was evaluated with simulation experiments. The results of laboratory evaluation indicate that the proposed methods offers a promising direction for tackling this complex issue.


AB An integrated real-time ramp metering model for nonrecurrent freeway congestion among link flows has been developed and tested in this study. The core concept of the proposed algorithm is to capture the dynamic traffic state evolution with a two-segment linear flow-density model. To be implemented in real time, an effective solution algorithm has been proposed for determining the time-varying metering rates. The entire algorithm has also been integrated with INTRAS, the most well-known freeway simulation model, for conducting simulation experiments. Preliminary research results indicate that the proposed integrated control model is promising because its effectiveness increases with the severity of accidents and the level of congestion. The model execution time is also sufficiently short for potential real-time operations.


AB This paper incorporates both the link capacity and first-in-first-out constraints into the dynamic user equilibrium problem. The corresponding dynamic equilibrium conditions for each origin-destination pair and time interval state that the generalized route travel times experienced by travelers are equal and minimal. A nested Lagrangian method embedding the gradient projection algorithm is then proposed and demonstrated with a numerical example. Index Terms-variational inequality, link capacity constraint, first-in-first-out requirement, dynamic user equilibrium, Lagrangian method, gradient projection algorithm.


AB In this paper, we study dynamic traffic assignment in real-time route guidance system. Many published literatures have examined this problem theoretically. Most of them can not used in route guidance for large-scale networks. Here we proposed a new dynamic traffic assignment method for large-scale networks. We call it quasi-dynamic traffic assignment. The process of dynamic assignment is basically simulated by means of virtue dynamic OD matrix.


AB A discrete-time predictive dynamic user-optimal departure time/route choice problem has been formulated and solved with the nested diagonalization method by Chen, H.K., Hsueh, C.F. (1998a. A discrete-time dynamic user-optimal departure time/route choice model. Transportation Engineering, ASCE 124 (3), 246-254). That model did not impose constraints on either departure times at origin or arrival times at destination, which are typically required for regular work trips. However, for better representing practical situations, the time-window constraints associated with both the departure times and arrival times, along with link capacity side constraints, need to be incorporated into the aforementioned model. The resulting dynamic capacitated user-optimal departure time/route choice model with time-window can appropriately model the queuing delay associated with each capacitated time-space link and also can properly differentiate off-peak and peak phenomena within the analysis period. A numerical example is provided for demonstration.

AB This paper is a follow-up study to the dynamic user-optimal departure time/route choice problem, by imposing hard time-windows on origin departure times and on destination arrival times. However, by an appropriate network representation, the dynamic user-optimal departure time/route choice problem with hard time-windows is mathematically equivalent to the dynamic user-optimal route choice problem and can be solved accordingly by the nested diagonalization method. The enhancements of the proposed model are that off-peak and peak phenomena within the analysis period can be properly differentiated and that the influence of earlier departures on latter ones can be naturally presented. A numerical example is provided for demonstration.


AB A stochastic/dynamic user-optimal route choice problem that assumes time-dependent route travel times Gumbel distributed is formulated by a variational inequality and the corresponding equilibrium conditions are introduced. Two K-shortest-path based heuristics called K-shortest-path (KSP) and restricted K-shortest-path (RKSP) are proposed and make comparisons with a link-based heuristic called stochastic dynamic method (SADA). Numerical examples show that both the KSP and RKSP are superior to the SADA in terms of total CPU time. While both the KSP and RKSP have fully taken the advantage of computational efficiency, the latter is more practical by taking into account the thresholds of an overlapping ratio and route travel time difference.


AB A discrete-time predictive dynamic user-optimal departure time/route choice model has been formulated and solved with the nested diagonalization method by Chen and Hsueh (1998a). That model did not impose constraints on either origin departure times or destination arrival times, which are typically required for regular work trips. For the purpose of better representing practical situations, the time-window constraints associated with both departure times and arrival times are incorporated into the previous dynamic user-optimal departure time/route choice model, resulting in a dynamic user-optimal departure time/route choice model with time-window, where the off-peak and peak phenomena can be properly differentiated within the analysis period, and the influence of earlier departures on later arrivals with respect to perceived route disutilities can be appropriately modeled.


AB The dynamic system-optimal route choice problem is formulated as a discrete-time link-based model using the variational inequality approach. This model complies with the dynamic system-optimal equilibrium condition in which for each origin-destination pair, the marginal route travel times experienced by travelers are equal and minimal. A nested diagonalization procedure is then proposed for obtaining the solution. Numerical examples are provided for showing equilibrated route travel times, demonstrating Braess's paradox and an approximating static counterpart solution. In addition, a two-stage procedure is used for computing a toll imposition such that a dynamic system-optimal is also a dynamic user-optimal solution.


AB This paper concerns a discrete-time, link-based, dynamic user-optimal departure time/route choice model using the variational inequality approach. The model complies with a dynamic user-optimal equilibrium condition in which for each origin-destination pair, the actual route travel times experienced by travelers, regardless the departure time, is equal and minimal. A nested diagonalization procedure is proposed to solve
the model. Numerical examples are then provided for demonstration and detailed elaboration for multiple solutions and Braess's paradox.


AB This paper formulates a discrete-time, link-based dynamic user-optimal route choice problem using the variational inequality approach. The proposed model complies with the dynamic user-optimal equilibrium condition in which for each origin-destination pair, the actual travel time experienced by travelers departing during the same interval is equal and minimal. A nested diagonalization procedure is then proposed and demonstrated with a numerical example.


AB The asymmetric traffic assignment model can improve the traditional traffic assignment model by adopting detailed network representation and more realistic asymmetric cost functions. The diagonalization, streamlined diagonalization, and projection methods are three widely mentioned solution algorithms for solving asymmetric traffic assignment models. The diagonalization and streamlined diagonalization methods have the advantage of requiring less computer memory but typically require greater computational time. The projection method has the advantage of converging more rapidly but requires a large computer memory. In order to balance computer memory and computational time, we propose two new algorithms; i.e., hybrid and streamlined hybrid methods. According to our case study, the proposed algorithms show their superiority over the diagonalization and streamlined diagonalization methods in terms of computational time, and over the projection method in terms of computer memory. Both new algorithms can handle small or medium networks sized asymmetric traffic assignment problems on personal computers.


AB The dynamic traffic control problem and the dynamic traffic assignment problem are integrated as a noncooperative game between a traffic authority and highway users. The objective of the combined control-assignment problem is to find a mutually consistent dynamic system-optimal signal setting and dynamic user-optimal traffic flow. The combined control-assignment problem is first formulated as a one-level Cournot game: the traffic authority and the users choose their strategies simultaneously. The combined control-assignment problem is subsequently formulated as a bi-level Stackelberg game. The traffic authority is the leader; it determines the signal settings in anticipation of the users' reactions. The users are followers who choose their routes after the signal settings have been determined. Finally, the system-optimal control-assignment problem is formulated as a Monopoly game. The sole player—the traffic authority—determines both signal settings and traffic flows to achieve a dynamic system-optimal solution. A numerical example is provided to illustrate the equilibria of the games.


AB A hybrid dynamic traffic assignment (HDTA) approach is presented that results in robust performance of the traffic network under various scenarios. The HDTA approach envisions a hierarchical routing decision process achieved through the careful interplay between a centralized DTA (CDTA) model and a decentralized DTA (DDTA) capability. The CDTA model supplies anticipatory a priori routing decisions, whereas the DDTA model generates locally optimized solutions online. Analytical and experimental analyses are conducted to illustrate the satisfactory performance of such an HDTA approach.

This paper presents a hybrid framework for Dynamic Traffic Assignment (DTA) problems. The Hybrid DTA problem (HDTA) is modeled as a Stackelberg Game, in which the Centralized DTA (CDTA) model is considered as the game leader and the Decentralized DTA (DDTA) model is the follower. Central to the analysis is the algorithm that provides approximate solution for the assignment problem in a realistic size network. Experiments are conducted and the solution features of the HDTA model are discussed.


This paper presents a finite difference method with variable time mesh for the hyperbolic traffic flow. The width of each time step is determined by the ratio of uniform space mesh size and maximal characteristic velocity. The proposed adaptive time mesh scheme is compatible with most of explicit finite difference methods. Numerical examples with different initial and boundary conditions of the Lighthill-Whitham-Richards (LWR) model and Payne-Whitham model are provided to contrast the effects of adaptive time mesh on the Lax-Friedrichs scheme. Simulation results are generally satisfied. The number of time steps of adaptive-Lax method is much less than that of Lax method with no significant difference in solutions of LWR model. Convergence of solution is readily claimed by the Courant-Friedrichs-Lewy (CFL) condition.


Traffic flow theory can provide real time prediction and evaluation of traffic management strategies. Lighthill, Whitham and Richards applied a fluid mechanism to traffic flow and proposed a dynamic model (LWR model) in 1955 first. However, the LWR model needs to couple with a specific speed-density relation to be solved. Sometimes the assumption of such a relationship is not consistent with the whole model. In this study, we develop a dynamic traffic flow model based on the continuity equation (LWR model) and second-order model. The assumptions of the system equations are consistent with each other. Therefore, a self-consistent system is proposed herein. The existence and uniqueness of the solution is also illustrated in this work. Numerical simulations are left for further studies.


This paper gives two simple traffic control examples to show that responsive control strategies may well increase urban traffic congestion and outlines a new method of fixing non-responsive signal timings. The paper illustrates the approach to near-equilibrium of a new micro-simulation/assignment program (RONETS; ROad NETwork Simulator) designed to assess UTC and road pricing schemes.


Research on how to model the dynamic behaviour of traffic flows efficiently and the development of algorithms to handle such models numerically has become a key activity in recent years as a consequence of the emerging applications of advanced technologies to transport. This paper offers a critical review of some of the most relevant formulations of the dynamic assignment problem and algorithms arising from both discrete and continuous models, emphasizing the underlying modelling hypothesis. Comments are made on the crucial underlying discussion on the basic implicit or explicit hypothesis and extensions to Wardrop's principle and the corresponding equilibrium concept. Properties and shortcomings are described and commented on and in some cases illustrated with simple examples. The paper ends with a description of a recent continuous modelling proposal that seems to overcome one of the reported major shortcomings: the FIFO discipline observance of traffic flows. A set of concluding remarks and a comprehensive bibliography close the paper.


We discuss the combination of an event-driven multimodal dynamic traffic model (PACSIM) with models for the estimation of pollution caused by exhaust gasses in a urban environment. Then nature of the PACSIM model and the reasons for considering it in the framework of pollution assessment are first discussed. We then consider the particular pollutant emission models used and discuss their scope and parameters, as well as the availability of the latter within PACSIM. We conclude the paper by illustrating the use of the combined traffic/pollution model in the context of a speed enforcement policy within selected urban neighbourhood zones.


This paper reports fundamental aspects and implementative problems of dynamic transit assignment models. The first part describes the main features of the dynamic approach; successively dynamic network loading and equilibrium models are reported, as well as the relative algorithms of flow computation. Finally, algorithm convergence conditions are analysed and application results on a real-size test network are presented.


In this paper a Stochastic Network Loading model that uses a dynamic approach to the simulation of transit services is presented. The model allows to consider the within day time-dependencies of demand and supply services for high frequency transit systems; it takes also into account the presence of ITS (Intelligent Transport Systems) that reflects on regularity/punctuality of services and on user behaviour at stops due to the presence of information at stops. The paper includes the description of the used supply network model, the specified path choice model and the behavioural hypotheses on which it is based, as well as a Dynamic Network Loading (DNL) procedure and an application to a real size network.


Time-dependent shortest path problems arise in a variety of applications; e.g., dynamic traffic assignment (DTA), network control, automobile driver guidance, ship routing and airplane dispatching. In the majority of
cases one seeks the cheapest (least generalized cost) or quickest (least time) route between an origin and a destination for a given time of departure. This is the "forward" shortest path problem. In some applications, however, e.g., when dispatching airplanes from airports and in DTA versions of the "morning commute problem", one seeks the cheapest or quickest routes for a given arrival time. This is the "backward" shortest path problem. It is shown that an algorithm that solves the forward quickest path problem on a network with first-in-first-out (FIFO) links also solves the backward quickest path problem on the same network. More generally, any algorithm that solves forward (or backward) problems of a particular type is shown also to solve backward (forward) problems of a conjugate type.


AB This paper explores some of the traffic phenomena that arise when drivers have to navigate a network in which queues back up past diverge intersections. If a diverge provides two alternative routes to the same destination and the shorter route has a bottleneck that generates a queue, one would expect that queue to stabilize at an equilibrium level where the travel time on both routes is roughly equal. If the capacity of the alternative route is unlimited then, this network can accommodate any demand level. However, if the bottleneck is so close to the upstream end of the link that the equilibrium queue cannot be contained in the link, then, the trip time on the queued route cannot grow to match that on the alternate route. This means that the alternative route can never be attractive, even if the queue spills back past the diverge, and that drivers approaching the diverge will act as if the alternative route did not exist. As a result, a steady flow into the system greater than the capacity of the bottleneck will cause a queue to grow all the way back to the origin (blocking it). The final result is an "oversaturated static state" where the queue regulates the input flow into the system. Curiously, if the bottleneck capacity of this network is reduced below a critical level (or is eliminated altogether) then the alternative route becomes attractive again and the system cannot reach the saturation point. This phenomenon is explored in the paper, where it is also shown that: i) a network can become permanently oversaturated/undersaturated as a result of a temporary increase/decrease in link capacity, ii) even under the most favorable assumptions, and in contrast to the equivalent assignment problem with point queues, a network can be stable both in an oversaturated and an, undersaturated state, and iii) temporary endogenous disturbances can permanently reverse the saturation state of a network. These findings suggest that in certain situations the time-dependent traffic assignment problem with physical queues is chaotic in nature and that (as in weather forecasting) it may be impossible to obtain input data with the required accuracy to make reliable predictions of cumulative output flows.


AB This article shows how the evolution of multi-commodity traffic flows over complex networks can be predicted over time, based on a simple macroscopic computer representation of traffic flow that is consistent with the kinematic wave theory under all traffic conditions. The method does not use ad hoc procedures to treat special situations. After a brief review of the basic model for one link, the article describes how three-legged junctions can be modeled. It then introduces a numerical procedure for networks, assuming that a time-varying origin-destination (O-D) table is given and that the proportion of turns at every junction is known. These assumptions are reasonable for numerical analysis of disaster evacuation plans. The results are then extended to the case where, instead of the turning proportions, the best routes to each destination from every junction are known at all times. For technical reasons explained in the text, the procedure is more complicated in this case, requiring more computer memory and more time for execution. The effort is estimated to be about an older of magnitude greater than for the static traffic assignment problem on a network of the same size. The procedure is ideally suited for parallel computing. It is hoped that the results in the article will lead to more realistic models of freeway flow, disaster evacuations and dynamic traffic assignment for the evening commute.

AB This article examines a general form of link travel time functions considered in the dynamic traffic assignment literature and shows that it only makes some physical sense in the special case where each function denotes either a link with no spatial dimension containing a point queue or a link with constant travel time and no queueing. Roadway segments exhibiting both phenomena must be represented by two links in series.


AB A qualitative description is presented of queuing patterns under an idealized scenario analogous to the evolution of traffic congestion during the morning peak hour in a long corridor leading to a single destination. The simplicity of the scenario allows the results to be verified independently by hand. Initially the corridor is assumed to consist of a single freeway. Traffic is generated at the freeway's many on-ramps during a short period and then is assumed to subside. Capacity limitations create queues on the ramps and the freeway, whose evolution is then described. A special case with just a few parameters is analyzed in detail. The solution obtained under the assumptions of the hydrodynamic theory of traffic flow (which explicitly recognizes vehicle storage limitations on the freeway) is shown to be drastically different from the solution obtained using 'point queue' models, which ignore these limitations. Because the latter models are currently a favored approach in the dynamic traffic assignment literature, results of this study illustrate the need for reevaluating the conditions under which current theories may be applicable. The effect that a slower parallel arterial would have on the system's traffic is also discussed. It was found that a route choice mechanism in which drivers do not anticipate the system's evolution leads to unreasonable traffic patterns - that is, patterns that would not be expected in reality. The anticipation phenomenon must thus be incorporated into any realistic model of dynamic network flows, which unfortunately, increases the difficulty of developing detailed control strategies.


AB In this paper we aim to present a model of spatially distributed economic markets under the assumptions that each demand market becomes a supply market after the time Delta. This problem is expressed by a time-dependent variational inequality for which we provide existence theorems and an example of computational procedure.


AB In this paper, we present different equilibrium models (the traffic equilibrium model in the static, in the dynamic and in the continuum case, the market equilibrium problem in the static and in the dynamic case) and we find the variational inequality related to each problem. We propose also a computational procedure for the calculation of the equilibrium solution and present the dual formulation of the variational inequality related to the traffic equilibrium problem.


AB Dynamic user equilibrium has received considerable theoretical attention for morning peak-period travel but very little for the evening peak. In an attempt to redress this imbalance, morning and evening travel are characterized and compared by using Vickrey's bottleneck model. To focus ideas, it is assumed that morning and evening travel differ in just one respect: scheduling preferences for the morning are defined in terms of arrival time at work, whereas preferences for the evening are defined in terms of departure time from work. Sufficient conditions are identified for the existence and uniqueness of a deterministic dynamic user equilibrium in terms of departure times for the morning and evening peaks. These conditions, which go well beyond previous work, involve relatively general assumptions about the schedule delay cost functions for morning and evening and essentially no restrictions on the degree of heterogeneity in trip-timing preferences of
travelers. Plausibility of the conditions is examined in light of the limited empirical evidence. A numerical example is developed at length to illustrate the importance of traveler heterogeneity and the extent of differences between morning and evening in the time pattern of departures and aggregate travel costs.


AB This paper presents an application of the dynamic car traffic simulator METROPOLIS, which describes departure time choices as well as route choices. It proposes a procedure for its calibration. This calibration procedure is based on survey and static data. Goodness of fit with respect to empirical data is measured with several criteria. The paper presents results for the case study of the Paris region.


AB Previous authors have considered the basic bottleneck model with one origin, one destination, and one link and shown that an equilibrium exists for the time of usage. In this paper we briefly review these results and introduce several intuitive day-to-day adjustment processes. Using numerical examples, we show that these adjustment processes never converge towards the solution of the basic bottleneck model. However, convergence occurs when the amount of heterogeneity in the driver's behavior is large enough. We hope that these results will provide some useful insights to researchers developing large-scale dynamic network equilibrium models.


AB We consider the existence, characterization, and calculation of equilibria in transportation networks, when the route capacities and demand requirements depend on time. The problem is situated in a Banach space setting and formulated in terms of a variational inequality.


AB It is well known that traffic flows, vehicles speed and acceleration closely concern traffic pollution. Therefore, calculating these characteristics as precise as possible is really relevant when dealing with such a phenomena. Usual tools in computing the values of traffic characteristics are traffic assignment models. A relevant component of these models are networks loading models allowing to calculate link flows from path flows. Existing networks loading models can be divided into aggregate and disaggregate models (microsimulation models). The latter ones allow the car-following and then a precise calculation of traffic parameters but they need considerable computing resources. In this paper, a mesosimulation model has been developed to study the flows propagation on the network. Since the proposed model is disaggregate as for flow characteristics and aggregate as for links performances, it does not need great computing resources in calculating vehicular speed and acceleration. Therefore, utility of this model entirely appears when dealing with simulation of traffic pollution.

A study in which the dynamic assignment model 3DAS was used as a planning tool is described. The Virginia part of the Washington, D.C., metropolitan area was chosen for the study. This area offers a heavily congested urban network with several rerouting possibilities. On the basis of available data it was decided to calculate a morning peak hour from 5:00 until 11:00 a.m. in 24 periods of 15 min each. The results show that the use of dynamic assignment for planning purposes can be very helpful. Dynamic assignment gives more detailed information than static assignment methods about the occurrences of traffic jams, and a more precise location and cause of congestion can be identified. Advanced traffic management system measures, introduced to alleviate the congestion, can be simulated, and all kinds of evaluations are possible, such as influences on travel time and jam length and effects of ramp metering and rerouting. Dynamic assignment, however, requires more accurate data and more computing time. Also very important is the ability to visualize the results. A dynamic assignment model gives flows in time. The best way to analyze the results is to present them in a movielike fashion. This requires a computer with a powerful graphics capability. For advanced traffic management systems to be successful more data and better (three-dimensional) origin-destination matrices are needed. New methods for origin-destination estimation and data from more induction loops and probe vehicles will improve the reliability of the results.


This paper presents a quickest path tree algorithm designed for real-time use with urban road networks. Using piecewise linear functions to model arc times as a function of time-of-day, the algorithm finds a quickest path and its associated earliest arrival time from the origin node to every other node in the network, and for every desired departure time from the origin. Using sensitivity analysis, it transforms the min path tree for one departure-time interval into another for the next adjacent interval, whose width the algorithm determines on the fly. By building trees for only relatively few departure times, it determines quickest paths for every departure time. Preliminary tests show the algorithm running upwards of ten times faster than the conventional approach.


This paper presents a dynamic model that characterizes the changing states of traffic volumes, design capacities, and pavement conditions in a transportation network's major commuting arteries. It also portrays the evolution of two system-wide effects—total vehicle miles travelled (VMT) and volatile organic compound (VOC) emissions—and accounts for lagged adjustments in travel behavior in its disequilibrium formulation. The model can be employed in optimal control exercises to determine what steps ought to be taken, when and where, and by how much in order to achieve planning objectives. Specifically, the model can be used to determine optimal combinations of traffic demand management measures, lane widening, and highway maintenance for achieving desired peak-period congestion levels, reducing VMT and VOC emissions to levels mandated by the Clean Air Act Amendments (CAAA), and keeping pavement conditions at acceptable serviceability ratings. Information on intertemporal tradeoffs between planning objectives, now required by the Intermodal Surface Transportation Efficiency Act (ISTEA), is generated in solutions to such exercises. We discuss how the model can be operationalized and illustrate its practicability with a small empirical example.


The study of dynamic route guidance model over a general road network has been deployed for some time in Intelligent Transportation Systems (ITS) field. This paper presents the general formulation of the system optimal dynamic traffic assignment (DTA) problems, and enunciates the discrete form model. For the sake of computational convenience, the simplification of the model is explored according to the characteristics of realistic traffic system. Then the algorithm base on Lagrangian relaxation and Quasi-Newton Iteration is
given to solve the simplified problem. Simulation is carried on to show the practicability and efficiency of the algorithm. Moreover some analysis on the simulation and guidance for future studies are presented at the end.


AB This paper deals with the modelling of the Dynamic Traffic Assignment Problem (DTAP) for analyzing the day time varying flows of urban transportation networks. During the past two decades, many models have been proposed in the literature, but some of them are based on heuristic concepts, and most of them incorporate important limitations. In this paper, we propose a Dynamic Traffic Assignment Model which is mainly based on the following assumption: the time spent by a vehicle on a link may be decomposed into a fixed travel time and a waiting time. The fixed travel time is the free flow travel time, after which vehicles are put in the link exit queue, until there is room for them to proceed their trip. We show that this model leads to a network structure (a temporal expansion of the base network, including the queues), and then formulate the DTAP as a network equilibrium problem over the expanded network. The mathematical formulation is achieved through a variational inequality where the variables are the path (or link) flows over the space-time expanded network. Numerical results show that the model may handle large networks, so it may be used in practice to analyze the traffic congestion moves in real cities, as well in space (physical links) as in day time.


AB This paper is concerned with the modeling of the Dynamic Traffic Assignment Problem (DTAP) for predicting the flows of urban transportation networks, mainly at peak periods. During the past 40 years, most of the research has been for the Static Traffic Assignment Problem (STAP) where it is assumed that demand is constant over time. This assumption is realistic for the analysis of intercity freight transportation networks over long periods of time, but it does not hold in an urban area, for simulating the flow variations during short periods (peak hours). Hence, during the past 20 years, the interest to the DTAP has been increasing. The seventies have been a transition period between heuristic models (where the demand is assigned to instantaneous minimum cost paths), and optimization models that take into account the demand over the whole study horizon of time, but all of them incorporate important limitations (only one destination; unrealistic conditions on the cost functions so that the flow "reaches" the destination; possible violation of the link capacities; etc.). In this paper, we propose a Dynamic Traffic Assignment Model which is mainly based on the following assumption: the time spent by a vehicle on a link may be decomposed into a fixed travel time plus a waiting time. The fixed travel time corresponds to the free or uncongested travel time over the link. Then the vehicle is put in an exit queue (which resides on the same link) until it becomes possible to enter a forward link; this decision is based on the link costs and their capacities. We show that this model leads to a network structure (a temporal expansion of the base network, including the queues) and therefore the DTAP may be viewed as a "simple" STAP over the expanded network. Hence, all the theories developed during the past 40 years for the STAP may be used to solve the DTAP.


AB Since strictly optimal (first-best) road pricing policies require information that we will probably never have, it is important to investigate what can be done under more restrictive assumptions as to what information is available. One such case is examined in this paper, where the main restrictive assumptions are that all users have the same choice set and that all alternatives have the same monetary cost. Individuals have utility functions with constant marginal utilities of time and money, but these marginal utilities vary across individuals, and are assumed to be unobservable. We show that for this model, any toll reform that reduces aggregate travel time and redistributes the toll revenues equally to all users makes everyone better off. This holds regardless of the distribution of marginal utilities of time and money, and for any road network.

AB Introducing real time traffic information into transportation network makes it necessary to consider development of queues and traffic flows as a dynamic process. This paper initiates a theoretical study of conditions under which this process is stable. A model is presented that describes within-one-day development of queues when drivers affected by real-time traffic information choose their paths en route. The model is reduced to a system of differential equations with delay. Equilibrium points of the system correspond to constant queue lengths. Stability of the system is investigated using characteristic values of the linearised minimal face flow. A traffic network example illustrating the method is provided.


AB Interest in the temporal modeling of road traffic has increased over the past decade due to the need to model traffic dynamics for the purpose of evaluating a variety of ITS components, such as traffic control measures and route guidance. A number of different approaches are available, including macroscopic, mesoscopic and microscopic traffic models, as well as analytical dynamic assignment models. Although microscopic models are the most detailed and realistic, they are difficult to calibrate and may not be the most practical tools for large-scale networks. This paper investigates three methods for dynamic network loading that are considerably less detailed than microscopic modeling. Each of the three methods is based on a different approach to modeling traffic dynamics: link-based travel time functions, the cell-transmission model, and a link-based model derived from a simplified car-following relationship. A small test network was devised and the results from each model were compared to those obtained with a microsimulator (INTEGRATION). Interpretation of the discrepancies observed in the results gave some indication of the relative importance of the different components of the three traffic models presented.


AB Analyzing the behavior of socio-technical systems - large urban populations interacting under constraints imposed by technical infrastructure - poses many interesting problems. We describe why simulation is an appropriate experimental method for studying these systems, drawing examples from the development and implementation of the Transportation Analysis and Simulation System (TRANSIMS). TRANSIMS is an urban planning tool that combines census data and household surveys with a description of the transportation network to produce estimates of human mobility. It iteratively evaluates hundreds of thousands of coupled non-linear models to produce a solution to a million-person game.


AB This paper presents the development of a Dynamic Traffic Simulation model as the heart of a comprehensive Route Guidance System (RGS) with behavioral and information supply components. An event-based dynamic traffic simulation model was built to account for the dynamics of traffic flow. The complex and changing state of traffic under both recurring and incident-related congestion(s) have been captured by analyzing traffic in multiple time periods. It also has the capability to predict traffic in advance for both the RGS-equipped and unequipped vehicles. The model developed in this research was validated on two networks. The first was a hypothetical network consisting of nine nodes and eleven links, and the second was a real-life network from southwestern Maryland that consists of 44 nodes and 132 links. A comparative analysis of the measures of effectiveness, such as total travel time, total vehicle miles of travel(VMT), travel time per VMT,
average speed, fuel consumption, and environmental emissions. revealed that the performance of the developed RGS is significantly better than the performance under existing non-RGS conditions. Several conclusions were drawn from this research. It was shown that under congestion conditions, the RGS with an appropriate mix of information supply strategies can be considered as a surrogate for capacity enhancement. A more realistic representation of the traffic system, including traffic flow and network attributes, has also been captured in the framework for RGS. Moreover, the modular construction of the program wherein different modules can be integrated or removed fairly easily allows the developer to reconfigure the program to perform specific functions or achieve certain performance characteristics. The RGS developed in this project can be used in conjunction with improving freight operations, network evaluation, transit information systems, emergency response vehicles and logistics operations.


AB This note considers alternative methods for computing Wardropian (traffic network) equilibria using a multicommodity formulation in nonlinear program and complementarity formats. These methods compute exact equilibria, they are efficient and they can be implemented with standard modeling software.


AB An analysis is made of a problem of traffic assignment within a queueing system with multiple service facilities subject to a changing load. The evolution in time of the mean number in the system is approximated with a nonlinear differential equation. The dynamic flow pattern is found for which the total waiting time of all entities passing the system is minimal. A numerical example is given. For the system in a nonstationary environment the adaptive strategy developed is compared with the performance of the policy of joining the shorter queue.


AB The evaluation of ITS measures, such as advanced Traveler Information Systems (ATS) and Advanced Traffic Management Systems (ATMS) depend heavily on the use of faster than real time traffic simulation methods. Although many microsimulation traffic models have already been developed [1, 7, 8, 9], their execution times are still too slow for large-scale ITS applications. This has lead to the development of mesoscopic simulation and traffic assignment methods [2, 3, 4]. These are simpler traffic models, which trade off some of the fidelity of the results for significant gains in computation time. This paper presents a new dynamic traffic assignment model that is based on the mesoscopic space-time queue network loading method developed by Mahut [6]. This hybrid optimization simulation method was applied to a portion of the Stockholm road network, which consists of 220 zones, 2080 links and 5000 turns.


AB This paper provides a succint statement of the deterministic dynamic disequilibrium network design problem. The formulation developed here is currently the subject of an effort to provide numerical tools for optimal dynamic infrastructure capital budgeting. We also present a numerical solution of a small example model using a discrete multigrid optimization approach.

This paper reviews two classes of nontraditional models for the (dis)equilibrium network design problem and uses these to describe research needed to advance the state-of-the art in the design of both static and dynamic networks. The static equilibrium design model emphasized herein recalls an important earlier result that allows the equilibrium network design problem to be stated as a single level mathematical program (SMP), a result which is surprisingly little known; it also introduces for the first time nonseparable elastic transportation demands and attendant difficulties in evaluating the consumers' surplus line integral. The dynamic, disequilibrium network design model emphasized herein maintains the usual design objective of maximizing some measure of social welfare, but recognizes that traffic on a network is not necessarily in equilibrium and that capacity changes to the network must induce transient phenomena not captured by invocation of the static version of Wardrop's first principle (user equilibrium). It is argued that such disequilibrium models by their very nature avoid temporal versions of Braess' paradox familiar from static equilibrium design and are naturally formulated as optimal control problems. Moreover, properly formulated disequilibrium design models are shown to overcome difficulties associated with evaluating the consumers' surplus line integral. Furthermore, when the associated disequilibrium dynamics are stable, these optimal control formulations are observed to be capable of computing static equilibrium network designs.


We are concerned in this paper with creating a dynamic description of interregional commodity movements which has steady states consistent with the traditional Samuelson-Takayama-Judge (STJ) static spatial price equilibrium model. This is accomplished by introducing a disequilibrium adjustment mechanism which differs from that of other network spatial price tatonnement models in that prices and interregional flows follow distinct signals, and constraints ensuring balanced trade flows are not enforced prior to attaining an equilibrium. The disequilibria arising from our relaxation of the flow balance constraints are seen to provide a foundation for describing failures of spatial markets to clear. Also notable among the features of our model is its treatment of a general network topology and non-separable cost, supply and demand functions. We show through numerical experiments that the proposed adjustment process is seen to hold promise as means of calculating static spatial price equilibria. Furthermore, we discuss the circumstances under which disequilibrium states visited by the adjustment process describe actual time-varying commodity Bows and prices, allowing the model to be used for predictive dynamic interregional freight modeling.


In this paper, we set forth certain axioms for a positive theory of dynamic urban network flows. We then show that mathematical models which fulfill these axioms may be created by adapting and extending certain fundamental notions from microeconomics and nonlinear systems theory. We further show that models created in this fashion, using concepts of fast and slow dynamic processes, may be manipulated into a variety of mathematical forms, thereby providing a synthesis of dynamic systems, variational inequality and control theoretic perspectives for predicting dynamic urban network flows. We close with a discussion of the implications of this synthesis for route guidance and intelligent vehicle infrastructure. Throughout, our presentation is at a conceptual level; the mathematical arguments are purposely not rigorous to embrace the widest possible readership.


In this paper we present tatonnement models for calculating static Wardropian user equilibria on congested networks with fully general demand and cost structures. We present both a qualitative analysis of stability and numerical studies which show that such an approach provides a reliable means for determining static user equilibria. We also describe circumstances for which these models depict day-to-day adjustments from one realizable disequilibrium state to another and how these adjustment processes differ depending on the
"quality" of the information being provided by (abstract) traveler information systems. Specifically, we demonstrate that such dynamic adjustment processes settle down to equilibria both when information is complete and when it is incomplete.


AB In the present paper we are concerned with developing more realistic dynamic models of route choice and departure time decisions of transportation network users than have been proposed in the literature heretofore. We briefly review one class of models that is a dynamic generalization of the static Wardropian user equilibrium, the so-called Boston traffic equilibrium. In contrast, we then propose a new class of models that is also a dynamic generalization of the static Wardropian user equilibrium. In particular, we show for the first time that there is a variational inequality formulation of dynamic user equilibrium with simultaneous route choice and departure time decisions which, when appropriate regularity conditions hold, preserves the first in, first out queue discipline.


AB This paper examines the problem of routing a given vehicle through a traffic network in which travel time on each link can be modeled as a random variable and its realization can be estimated in advance and made available to the vehicle's routing system before it enters the link. The underlying problem is formulated as the closed-loop adaptive shortest path routing problem (CASPRP) with the objective of identifying only the immediate link, instead of a whole path, to account for the future availability of travel time information on individual links. Having formulated the problem as a dynamic program and identified the associated difficulties, we apply an approximate probabilistic treatment to the recurrent relations and propose a labeling algorithm to solve the resultant equations. The proposed algorithm is proved theoretically to have the same computational complexity as the traditional label-correcting (LC) algorithm for the classic shortest path problems. Computational experiments on a set of randomly generated networks and a realistic road network demonstrate the efficiency of the proposed algorithm and the advantage of adaptive routing systems.


AB Whether or not the general asymmetric variational inequality problem can be formulated as a differentiable optimization problem has been an open question. This paper gives an affirmative answer to this question. We provide a new optimization problem formulation of the variational inequality problem, and show that its objective function is continuously differentiable whenever the mapping involved in the latter problem is continuously differentiable. We also show that under appropriate assumptions on the latter mapping, any stationary point of the optimization problem is a global optimal solution, and hence solves the variational inequality problem. We discuss descent methods for solving the equivalent optimization problem and comment on systems of nonlinear equations and nonlinear complementarity problems.

AB In this paper the authors investigated two possible applications of neural networks in order to improve the promptness and the accuracy of Advanced Traveler Information Systems (ATIS) and Advanced Traffic Management Systems (ATMS), in particular during the phase of their initial diffusion. In case of complete diffusion, the ATIS/ATMS so involve a Dynamic Assignment Model, which neural networks could also provide with quick real-time O-D matrix estimates.


AB In this paper a decentralized pure reactive scheme for dynamic route guidance of vehicles in a urban road network is proposed. The overall scheme is implemented trough a set of decisional agents, one for each node at which different routing choices are possible. For each of such nodes an optimization problem is stated and solved, at the beginning of each interval time, whose objective is to determine the optimal splitting rates or vehicles incoming that node, for each possible final destination. The main objective of such a problem is to minimize the total travel time spent by each of the incoming vehicles. The overall control scheme is based on the solution of a single node optimal control problem. The coordination among the single node controllers is ensured by a procedure for information exchange.


AB Stochasticity is prevalent in transportation networks in general, and traffic networks In particular. We develop a policy-based stochastic Dynamic Traffic Assignment (DTA) model and related solution algorithms. The DTA model works in a stochastic time-dependent network where link travel times are time-dependent random variables. Routing policies rather than paths are used as users' routing choices. A routing policy is a decision rule which specifies what node to take next out of current node based on current time and realized link travel times. We first give a conceptual framework for the DTA model. We then develop generic models for the routing policy generation problem, users' policy choice problem and dynamic network loading problem, which are the three major components of the overall DTA model. We then present a heuristic algorithm to solve the proposed policy-based DTA model. Using an example, we show that policy-based DTA models have solutions different in expected travel times than the path-based models which are commonly used in the literature.


AB In this paper, we further analyze and prove the stability and convergence of the dynamic system proposed by Friesz et al, whose equilibria solve the associated variational inequality problems. Two sufficient conditions are provided to ensure the asymptotic stability of this system with a monotone and asymmetric mapping by means of an energy function. Meanwhile this system with a monotone and gradient mapping is also proved to be asymptotically stable using another energy function. Furthermore, the exponential stability of this system is also shown under. strongly monotone condition. Some obtained results improve the existing ones and the given conditions can be easily checked in practice. Since this dynamic system has wide applications, the obtained, results are significant in both theory and application.

We introduce a novel procedure to compute system optimal routings in a dynamic traffic network. Fictitious play is utilized within a game of identical interests wherein vehicles are treated as players with the common payoff of average trip time experienced in the network. This decentralized approach via repeated play of the fictitious game is proven to converge to a local system optimal routing. Results from a large-scale computational test on a real network are presented.


Intelligent transportation programs take many different names throughout the world; in the United States it is ITS, in Europe it is Prometheus, and in Japan it is AMTICS and RAGS. All of them share very similar objectives, i.e., the development of advanced Traffic Management Systems, Traveler Information Systems, Vehicle Control Systems, Commercial Vehicle Operations, Public Transportation Systems, and Rural Transportation Systems. Several key technologies stand to serve the synthesis of each and every one of these objectives. These technologies are: Digital Maps, Computers, Path Planning, Human Factors, Sensors, Communications, Vehicle Control, and Traffic Control. This paper discusses each one of these subjects in enough detail to provide the reader with an introduction to both the technology and its state-of-the-art. In addition, the paper discusses socio-politico-economic issues associated with the implementation of the various programs. We believe that this highly neglected subject will serve to temper the development and deployment of these programs.


Models of households' travel choices are an important focus of research. For some time, it has been known that such models need to incorporate how travel depends on activity choices. It is argued that production system models constitute an alternative or necessary complementary approach if the goal is to develop models of interdependent activity and travel choices, or activity scheduling, which are based on behavioral science theories of higher cognitive processes. Several computational-process models (CPMs) which implement production systems as computer programs are reviewed. Currently, no encompassing CPM exists but some may be possible to integrate in a descriptive model of activity scheduling.


Intelligent transportation systems (ITS) are being designed to provide real-time control and route guidance to motorists to optimize traffic network performance. Current research and development efforts consist of a dynamic traffic assignment capability that can predict future traffic conditions and a real-time traffic adaptive control system (RT-TRACS) for generation of signal control strategies. Although these models are intimately connected, so far they have developed independently of one another. A framework is presented here for integrating the two models into a combined system with a practical approach for realizing it. First the static case involving the interaction between travelers (demand) and transportation facilities (supply) under recurrent conditions is discussed. This model is applicable in the design and planning of transportation systems management actions. The framework is then extended to the quasidynamic and the dynamic cases, which involve incorporation of advanced TTS technologies in the form of advanced traffic management systems and advanced traveler information systems. An innovative application of this framework to advanced traffic-adaptive signal control is presented using the hierarchic structure of RT-TRACS.


An iterative algorithm to determine the dynamic user equilibrium with respect to Link costs defined by a traffic simulation model is presented. Each driver's route choice is modeled by a discrete probability
distribution which is used to select a route in the simulation. After each simulation run, the probability distribution is adapted to minimize the travel costs. Although the algorithm does not depend on the simulation model, a queuing model is used for performance reasons. The stability of the algorithm is analyzed for a simple example network. As an application example, a dynamic version of Braess's paradox is studied.


AB The aim of this paper is to seek efficient and effective numerical methods for computing link outflow rates under continuous dynamic loads. Three methods are proposed and their respective properties are investigated, theoretically and numerically. Furthermore, some implications are presented for dynamic traffic assignment problem solving.


AB We consider an example to show that the minimum instantaneous cost path principle, as suggested in Friesz et al. [1] for generalising Wardrop's first principle to the dynamic state, may cause some drivers' routes to "loop". These looping routes traverse the same link more than once - indeed, in our example six times.


AB We describe a deterministic queueing assignment model which seeks to reduce total travel delays in a road traffic network by routeing drivers according to the total delay caused on each link (the local marginal delay). The model is approximate and is applicable to networks with many origin-destination pairs and many bottlenecks. Optimality of the solution determined by the model is discussed. It is particularly shown that, unlike in the steady state (Dafermos and Sparrow, 1969), reducing total travel times by using the local marginal delay will not generally result in an optimal solution. Results are provided for two networks.


AB We present an approach to solving the dynamic network loading problem (DNLP). The approach views the roadway in terms of the underlying densities, segmenting the roadway into blocks of constant density. Using hydrodynamic theory, we describe how these blocks can be used to provide a solution method to the DNLP with a continuous representation of space and time which is readily implementable. This solution method provides an exact solution with piece-wise linear link travel times. We present a pseudocode description of the algorithm and discuss a sample computer implementation.


AB Cars which are delayed in bottlenecks cannot be present downstream at the same time. In traditional assignment-models, cars are assigned to the whole route and therefore are present at the same time on all links on that route. This can give less good outcomes of the calculations in some cases. If the assignment is done in
space with time as third dimension, the problem of the less good assignment can be overcome. The first part of the paper gives a simple example of the equilibrium-assignment-model. This example shows that in some parts of the network congestion is unrealistically calculated as a consequence of bottlenecks upstream. The second part of the paper gives a description of the three-dimensional assignment-model. The proposed algorithm is additive to existing traditional assignment-models, although the algorithm deviates in some details. The effect of improving the capacity of bottlenecks on congestion downstream will be shown in two examples. A computer-model of the assignment-model works under MS-DOS on a micro-computer and can be demonstrated.


AB This paper investigates the requirements of dynamic traffic modelling, and proposes the deterministic queuing model as a plausible link performance function to describe the relationship between inflows, outflows, and link travel costs in time-varying condition. Then, it explains how we can perform logit-based stochastic network loading for general road networks in the dynamic case. In particular, this paper shows how to perform dynamic stochastic network loadings for many-to-many origin-destination pairs, and what should be considered to maintain correct flow propagation in the network loading process. Next, this paper shows how the stochastic dynamic user equilibrium (SDUE) assignment problem can be solved without direct evaluation of the objective function. For this purpose, a quadratic interpolation, the method of successive average, and the pure network loading method are adopted at the line-search step in the solution algorithm. Numerical examples show that the present SDUE assignment model with a quadratic interpolation gives rise to a convergent solution with good quality whilst needing less computation time. Furthermore, it is found that the predictive cost-flow association (Proceedings of the European Transport Conferences, Seminar F, P434, 1999, p. 79) is preferable to the reactive one because the former can produce consistent assignment patterns regardless of the size of dispersion parameter theta in the logit model for route choice.


AB This study aims at analyzing drivers' behavior in acquiring and using traffic information in an environment with multiple information sources. Accordingly, information acquisition and reference models are developed in an effort to show the empirical relationship between drivers' reaction to multiple information sources, causal factors latent psychological ones, traffic conditions at the time of traveling and the accuracy of traffic information available. A route choice model is proposed that takes into account the information acquisition and reference process. Model validity is investigated using data collected on the Tokyo Metropolitan Expressway, which has four different types of information sources.


AB This paper addresses the problem of integrating advanced traveller information systems (ATIS) and advanced traffic management systems (ATMS). A framework that allows the integration of existing successful control implementations is presented. This framework is utilised to integrate the ATIS/ATMS control decisions of two operational schemes, namely the ATIS stand-alone system, and the ATMS stand-alone control systems, and to form a dual non-cooperative supervisory traffic control system. The two operational schemes are formulated as bi-level optimisation problems. Approximate simulation-based optimisation algorithms are devised as representations of the existing control logic operating these schemes. The schemes' performance is assessed using a simplified network.

This paper is an attempt to address the issue of data flow interdependency and error propagation in Advanced Traveler Information Systems/Advanced Traffic Management Systems supporting simulation-based models. A complex dynamic simulation model constitutes a number of processes, variables, or parameters with varying impact on the model's state estimation accuracy. The overall model error might be attributed to the propagating internal system errors. This paper presents a framework for calibrating simulation models developed to support the dynamic traffic assignment systems. The calibration framework employs off-line analyses on the model processes, input, and system data, and the results are utilized to identify the model processes causing significant errors and to quantify the propagation of a specific variable error. The framework could be utilized to rank the model processes and their variables so that resources are allocated to calibrating significant error-causing entities. The framework is tested on a microscopic simulation model, MTSSIMA, and the results are discussed.


Markovian traffic assignment processes form an intuitively attractive and flexible class of models. However, the intrinsic complexity of these models (especially when applied to large road networks) make their theoretical analysis very difficult. Simulation of the process in question can be used to learn something of the characteristics of the assignment model, but such simulation is typically computationally expensive. Furthermore, interpretation of simulation results is often far from straightforward. For example, it is difficult to discover to what extent day-to-day variability in traffic flows can be attributed to travellers' reactions to changing mean travel costs, and to what extent these variations are simply explained by entirely haphazard fluctuations in individual travellers' preferences. Nonetheless, this is an important issue, not least because it is crucial in understanding how a Markovian assignment process will react to various types of one-off event (such as the temporary closure of a road link). In this paper a new analytical tool called the coefficient of reactivity is introduced. This coefficient summarises the extent to which traveller learning mechanisms provoke day-to-day volatility in Markovian assignment models. Properties of the coefficient of reactivity, and its more easily calculated asymptotic form, are discussed. Uses and interpretations of these new coefficients are illustrated through a number of examples.


A new approach is proposed to calibrate and validate the most critical components of a dynamic traffic assignment (DTA) model: dynamic route choice and flow propagation. By presenting approximate joint probability distribution functions of the temporal link traffic flows on a network, it is possible to derive the likelihood functions for estimating dynamic route choice and actual flow propagation. This approach also enables statistical tests to be performed for validation of DTA models. Both procedures are presented with a small numerical example and a larger network. These examples also indicate that it is possible to calibrate and validate a DTA model with detection errors and incomplete data, especially when real-time traffic counts are available on only a few links in the network.


We present simulations of congested traffic in circular and open systems with a non-local, gas-kinetic-based traffic model and a novel car-following model. The model parameters are all intuitive and can be easily calibrated. Micro- and macro-simulations with these models for identical vehicles on a single lane produce the same traffic states, which also qualitatively agree with empirical traffic observations. Moreover, the phase diagrams of traffic states in the presence of bottlenecks for the microscopic car-following model and the macroscopic gas-kinetic-based model almost agree. In both cases, we found metastable regimes, spatially coexistent states, and a small region of tristability. The distinction of different types of vehicles (cars and long vehicles) yields additional insight and allows us to reproduce empirical data even more realistically, including
the observed fluctuation properties of traffic flows like the wide scattering of congested traffic data. Finally, as an alternative to the gas-kinetic approach, we propose a new scheme for deriving non-local macroscopic traffic models from given microscopic car-following models. Assuming identical (macroscopic) initial and boundary conditions, we show that there are microscopic models for which the corresponding macroscopic version displays an almost identical dynamics. This enables us to combine micro- and macro-simulations of road sections by simple algorithms, and even to simulate them simultaneously.


AB We present a gas-kinetic (Boltzmann-like) traffic equation that is not only suited for low vehicle densities, but also for the high-density regime, as it takes into account the forwardly directed interactions, effects of vehicular space requirements like increased interaction rates: and effects of velocity correlations that reflect the bunching of cars, at least partially. From this gas-kinetic equation, we systematically derive the related macroscopic traffic equations. The corresponding partial differential equations for the vehicle density and average velocity are directly related to the quantities characterizing individual driver-vehicle behavior, and, as we show by calibration of the model, their optimal values have the expected order of magnitude. Therefore: the model allows to investigate the influences of varying street and weather conditions or freeway control measures. We point out that, because of the forwardly directed interactions, the macroscopic equations contain non-local instead of diffusion or viscosity terms. This resolves some of the inconsistencies found in previous models and allows for a fast and robust numerical integration, so that several thousand freeway kilometers can be simulated in real-time. It turns out that the model is in good agreement with the experimentally observed properties of freeway traffic flow. In particular, it reproduces the characteristic outflow and dissolution velocity of traffic jams, as well as the phase transition to "synchronized" congested traffic. We also reproduce the five different kinds of congested states that have been found close to on-ramps (or bottlenecks) and present a "phase diagram" of the different traffic states in dependence of the main flow and the ramp flow, showing that congested states are often induced by perturbations in the traffic flow. Finally, we introduce generalized macroscopic equations for multi-lane and multi-userclass traffic. With these, we investigate the differences between multi-lane simulations and simulations of the effective one-lane model.


AB The gas-kinetic foundation of fluid-dynamic traffic equations suggested in previous papers (D. Helbing, Physica A 219 (1995) 375 and 391) is further refined by applying the theory of dense gases and granular materials to the Boltzmann-like traffic model by Paveri-Fontana. It is shown that, despite the phenomenologically similar behavior of ordinary and granular fluids, the relations for these cannot directly be transferred to vehicular traffic. The dissipative and anisotropic interactions of vehicles as well as their velocity-dependent space requirements lead to a considerably different structure of the macroscopic traffic equations, also in comparison with the previously suggested traffic flow models. As a consequence, the instability mechanisms of emergent density waves are different. Crucial assumptions are validated by empirical traffic data and essential results are illustrated by figures.


AB A macroscopic model for dynamic traffic flow is presented. The main goal of the model is the real time simulation of large freeway networks with multiple sources and sinks. First, we introduce the model in its discrete formulation and consider some of its properties. It turns out, that our non-hydrodynamical ansatz for the flows results in a very advantageous behavior of the model. Next the fitting conditions at junctions of a traffic network are discussed. In the following sections we carry out a continuous approximation of our discrete model in order to derive stationary solutions and to consider the stability of the homogeneous one. It turns out, that for certain conditions unstable traffic flow occurs. In a subsequent section, we compare the stability of the discrete model and the corresponding continuous approximation. This confirms in retrospection the close
similarities of both model versions. Finally we compare the results of our model with the results of another macroscopic model, that was recently suggested by Kerner and Konhaeuser [Phys. Rev. E 48, 2335-2338 (1993)].


AB A considerable amount of the current IVHS traffic modeling research is focused on developing accurate and efficient dynamic traffic assignment models. Such models, while initially deployed off-line, are envisioned to be ultimately executed on-line based on realtime traffic data. Critical to such on-line applications of dynamic traffic assignments is the availability of real-time O-D data with known levels of accuracy. The practical and theoretical limitations of synthetic O-D generation techniques have led to an exploration of how such data could be derived from RGS equipped vehicles which act as probes by transmitting their origin and intended trip destination when they initiate a trip. This paper presents the details of an analytical approach to determining estimates of the mean of the population O-D demands and the reliability of such estimates. Equations that quantify the reliability of the O-D estimates are developed based on statistical sampling theory. These equations are developed for a general network, and are illustrated in detail for a specific example network consisting of an integrated arterial and freeway corridor. On the basis of the example network, it was found that even for a 20% level of market penetration, the average root-mean-square error between the estimated and actual O-D departure rates is 35% of the average actual O-D. In general, it can be concluded that for levels of market penetration that can be expected to be achieved in the initial stages of RGS implementation, O-D demands estimated solely on probe vehicle data will be of insufficient quality to be of significant operational benefit.


AB This paper discusses the application of the network traffic simulation model INTEGRATION to a 35-km section of Highway 401 in Toronto, Canada. Results for the eastbound direction from 4 a.m. to 12 noon are presented. Existing freeway conditions are quantified using data from the COMPASS freeway traffic management system and from a floating car travel time survey. Variations that exist in observed link flows and trip travel durations over time of day and day of week are examined. The extent to which COMPASS data meets the data requirements of the INTEGRATION model is examined. Since the current COMPASS system encompassed less than 50% of the network analyzed, complications arise in accurately estimating the prevailing time-varying origin-destination demands, as well as in comprehensively validating the simulation model's results. The present level of model calibration results in a correlation coefficient of estimated and observed link flows of 97.23%. This level of discrepancy is generally within the natural day-to-day variations that are inherent within the system. However, travel times estimated by the simulation model tend to be underestimated, particularly for the express lanes. Further model calibration, to improve the model's results, is deferred until more of the network is covered by COMPASS.


AB Intelligent transport systems provide various means to improve capacity and travel time in road networks. Evaluation of the benefits of these improvements requires consideration of travellers' response to them. We consider a continuous-time equilibrium model of departure time choice and identify a formula for the dynamic equilibrium department rate profile. We develop the analysis to consider the effect on the cost incurred by travellers of ITS measures through their effects on each of the travel time in the absence of congestion, and the capacity for travel. This shows the importance in choice of departure time of travellers' values of time at each of the origin and destination of their journeys. We show the importance of these values of time in evaluation, and that if travellers value their time at both the origin and destination of their journeys, their
responses will lead them to achieve a greater reduction in costs than would be achieved under free-flow conditions.


Dynamic traffic assignment provides a valuable means to investigate congested road networks and hence to develop traffic management measures for them. These methods have two distinct components: a traffic model, which represents the propagation of vehicles through the network, and a route choice model, which represents the drivers' response to the conditions that they encounter. We investigate the properties and suitability of various traffic models for use in dynamic assignment using an analysis based upon a dynamic extension of Wardrop's equilibrium condition for route choice. We consider various requirements of plausible traffic behaviour, notably conservation of traffic and dependence only on traffic downstream, and establish the crucial importance of the latter in the present context. General analytical results are complemented by calculations for simple example networks: this shows that the deterministic queueing and the kinematic wave models of traffic are suitable for this use, but that several other traffic models that are used widely give rise to dynamic assignments that have unacceptable characteristics.


We consider a dynamic traffic assignment problem in which congestion is modeled explicitly. It has been shown previously that the piecewise linearized problem can be solved by a sequence of linear programs. However, for the dynamic control of traffic networks, the dimensions of the resulting problems are likely to be prohibitive. Since the linear programs have the staircase structure, we propose to apply nested decomposition algorithms. The approach becomes particularly attractive with the advent of computers with multiple processors as the subproblems can be solved concurrently. In this paper, we demonstrate this application on an Intel iPSC/2 hypercube computer.


A dynamic model for the optimal control of traffic flow over a network is considered. The model, which treats congestion explicitly in the flow equations, gives rise to nonlinear, nonconvex mathematical programming problems. It has been shown for a piecewise linear version of this model that a global optimum is contained in the set of optimal solutions of a certain linear program. This paper presents a sufficient condition for optimality which implies that a global optimum can be obtained by successively optimizing at most N plus 1 objective functions for the linear program, where N is the number of time periods in the planning horizon.


The development of advanced traffic-management systems as a major component of intelligent vehicle/highway systems is targeted to address the complex problem of urban traffic congestion. The strategy includes real-time diversion of traffic during congestion-causing events, by making efficient use of the available capacities in the highway network. A conceptual framework for executing real-time diversions is presented in this paper. The strategy envisages on-line control and management of traffic through control centers and their surveillance equipment. The approach relies on real-time traffic data to detect incidents and develop rerouting plants to benefit motorists. For this purpose, a model has been developed to estimate traveler
destinations from traffic data. The dynamic nature of the problem is captured through a traffic assignment/simulation model, which can predict traffic conditions that would prevail in the alternate routes. A knowledge-based expert system is also proposed to estimate traffic delays, and to evaluate and choose alternate routes. This research is being applied to the northern Virginia urban area as a case study.


AB In contemporary traffic flow theory, the distinction between user classes is rarely made. However, we envisage that the accuracy and the descriptive power of the macroscopic traffic flow models can be improved significantly by separating user classes and their specific flow characteristics. As a consequence, the possibility of improved estimation and prediction of traffic flow conditions becomes available. Additionally, the availability of a realistic multiple user-class traffic flow model enables the automated generation of user-dedicated traffic control policies by means of mathematical optimal control theory. A macroscopic multiple user-class model is derived from mesoscopic principles. In opposition to earlier multiple user-class models, the model presented here implicitly defines equilibrium relationships between traffic density and equilibrium velocities as a function of current traffic conditions, traffic composition, and distribution of user-class-dependent desired velocities. Additionally, the velocity variance variable is introduced describing deviations from the average speed within the user classes. The multiple user-class model identifies competing processes. On the one hand, drivers attempt to traverse the freeway at their desired velocity; on the other hand, they adjust their velocity because of interaction with slower vehicles. These processes can result in self-formation of apparently random local structures. Finally, the proposed model satisfies the anisotropy condition and the invariant personality condition.


AB A day-to-day dynamic framework, in which the DYnamic Network Assignment Simulation Model for Advanced Road Telematics (DYNASMART) simulation-assignment model is applied to evaluate the performance of traffic networks, is developed to study network dynamics under real-time information and responsive signal control systems. The focus in this paper is primarily on commuter trips from home to work in a general network. Two levels of tripmaker decision-making processes are incorporated: (1) day-to-day dynamics and (2) real-time dynamics. Day-to-day dynamics consider the choices of departure time and route according to indifference bands of tolerable 'schedule delay', defined as the difference between the user's actual and preferred arrival times, and are thus governed by tripmakers' daily learning processes. Real-time dynamics consider en-route switching decisions in response to real-time information on prevailing traffic conditions. The resulting Bows could be used in updating the supplied real-time information as well as the traffic control parameters. Two types of traffic control responsiveness are evaluated: (1) daily adjustment of signal timing parameters to reflect the preceding day's traffic patterns; and (2) real-time traffic-responsive signal control driven by prevailing flow patterns. The framework is illustrated through numerical experiments to investigate the day-to-day evolution of network flows under real-time information and responsive signal control, and assess the effectiveness of such information in a proper dynamic perspective.


AB A day-to-day dynamic framework, in which the DYNASMART simulation assignment model was applied to evaluate the performance of traffic networks, was developed to study network dynamics under different information systems. Two levels of tripmaker decision-making processes are identified: (a) day-to-
day dynamics and (b) real-time dynamics. Day-to-day dynamics consider the choices of departure time and route according to indifference bands of tolerable 'schedule delay' defined as the difference between the user's actual and preferred arrival times. Real-time dynamics consider en route switching decisions. Numerical experiments were conducted to investigate the day-to-day evolution of network flows under real-time information and assess the effectiveness of such information in a proper dynamic perspective.


AB Although walking has been considered as an important transport mode, pedestrian modelling has received little attention in either academic or practising circles. There is an increasing need for methods that can be used to help the planning, design and management of pedestrian traffic systems. This paper presents a nonlinear programming formulation of the dynamic pedestrian equilibrium assignment problem based on the following assumptions. The pedestrian traffic system in a congested urban area can be modelled as a capacitated network with alternative walkway sections. People in this pedestrian network make such decisions as selecting departure time and walking path between origins and destinations (OD). The study horizon is divided equally into shorter time intervals of 5-10 minutes each, for which the pedestrian departure time matrices are given by a logit formula. It is dependent on the predetermined departure time costs and the equilibrium OD walking costs. In the proposed model, a 'quasi-continuous' technique is adopted to smooth out the transitions of various variables between time intervals and to satisfy the first-in-first-out discipline. A heuristic algorithm that generates approximate solutions to the model is presented. The numerical results in a real network shows that the model and algorithm proposed in this paper are able to capture the main characteristics of the departure time and route choices in congested unidirectional pedestrian traffic systems.


AB This paper considers a simultaneous route and departure (SRD) time choice equilibrium assignment problem in network with queues. The problem is modeled on discrete-time basis and formulated as an equivalent "zero-extreme value" minimization problem, in which the first-in-first-out (FIFO) behavior at intersection is guaranteed by proper formulation of the dynamic link travel times. A heuristic solution algorithm is proposed, which simulates a normal day-to-day dynamic system by a route/time-swapping process, thereby reaching to an extreme point of the minimization problem. The existence of discrete-time dynamic user-equilibrium (UE) solutions is investigated. The iteration-to-iteration stability of the proposed algorithm is discussed, together with numerical results on two example networks.


AB The application of a transfer function model (TFM) in a real-time dynamic traffic assignment system is investigated. The motivation is to improve the speed estimation method to enable better system consistency with reality in real-time operation. The study is conducted by adopting a TFM derived from actual detector data in San Antonio, Texas. This model is then used in the traffic simulation module of the DYNASMART-X dynamic traffic assignment system to update the network link speeds. A nonlinear least-squares optimization algorithm, implemented for this study, is coupled with DYNASMART-X to enable adaptive estimation of the TFM parameters. Simulation-based experiments are carried out on the Fort Worth test network. These experiments are designed to evaluate the TFM performance and to gain insight into its operational properties under different conditions. The results show that the TFM, both adaptive and nonadaptive, can consistently approximate the true underlying speed-density dynamics. Of significant importance is the transferability and robustness of TFMs in different settings. The outcome of this research substantiates the premise that good speed estimation can be achieved through the use of TFMs.

AB A decentralized controller for dynamic routing in multidestination transportation networks is presented. The proposed algorithm is especially suited for congested networks, where the traffic demand is close to or more than (at least for some duration of time, e.g., during a rush hour) the total capacity of the network. The basic aim of the introduced approach is to avoid queue build-up for as large external arrival rates as possible. It is shown that this problem can be formulated as a linear programming problem, and can be solved off-line. The proposed controller is decentralized in the sense that all the on-line computations are done locally at the nodes without any information transfer from the other nodes. Furthermore, no synchronization among the nodes is needed. The controller guarantees stability and clears the queues of the network in finite time assuming that the external arrival rates do not become larger than a maximum value. The controller also avoids looping.


AB Whether freeway ramp metering can reduce total travel time in a corridor of several alternative routes depends on changes in route volumes and travel times. Ramp metering effectiveness and ramp metering algorithms have been evaluated mainly on the basis of improved freeway operations. Most studies have not evaluated the impact on alternative routes because of the complexity of the problem (e.g., which routes and what lengths of routes should be studied). An analysis of ramp metering impact in a network corridor is presented, first for simple steady-state cases and then for more complex cases involving time-varying demand, upstream and downstream queueing on freeway and alternative routes, and variable ramp metering rates based on freeway conditions. Time-varying examples are solved with a dynamic traffic assignment model called DYMOD. The analysis shows that ramp metering yields total travel time savings if (a) downstream freeway capacities are sufficiently restrictive, and (b) competitive alternative routes exist to accommodate the diverted traffic. The conditions under which ramp metering can be effective is illustrated by an examination of these simplified cases, and a useful modeling approach to analyzing systemwide impact in a larger corridor is demonstrated.


AB Several variants of combined dynamic travel models in discrete time with dynamic user equilibrium or system optimality as the assignment objective have been presented recently. This modeling approach is converted into quasi-continuous time, which enables two key model improvements: (a) traffic volumes are spread over time intervals in continuous time, allowing trips to be split among successive time intervals, and (b) the first-in first-out ordering of trips between all zone pairs is more precisely maintained. The means by which capacity losses are approximated on upstream links caused by spillback queueing from oversaturated links and accidents are also described. Trips are assumed to have scheduled departure times and variable arrival times, but notational variations allowing other model forms are briefly mentioned. Application of this model to a Denver-area network with comparison of results to observed speeds and volumes is described elsewhere.


AB This paper examines the effects of dynamic user-equilibrium (DUE) traffic assignment with scheduled trip arrival times on network design outcomes in comparison to outcomes with steady-state travel demands. The objective is to minimize systemwide travel cost by considering alternative link improvements to an existing network (e.g., select among budget-constrained subsets of link-improvement candidates). DUE is a temporal generalization of static user-equilibrium (SUE) assignment with additional constraints to insure temporally continuous trip paths and first-in first-out (FIFO) trip ordering between all origin-destination pairs. Previous research has not investigated the effects of dynamic travel demands and schedule delay (i.e., shifts by
trips to earlier or later arrival times) on network design with multiple trip origins and destinations. DUE is formulated as a bilevel program of two subproblems solved successively by an iterative algorithm that consistently converges to solutions that closely satisfy the necessary optimality conditions of this problem. Examples show the impacts of alternative combinations of network changes affecting capacities and/or free-flow travel times (e.g., ramp metering or road widening) to depend on temporal travel demands and schedule delay distributions.


This paper formulates the problem of finding the most likely distribution of origin-destination (O-D) specific link volumes (called "link uses") from equilibrium assignment. Although an equilibrium assignment is unique in terms of aggregate link volumes, trips between different O-D pairs assigned to alternative paths between any node pair can be swapped among these paths such that total link volumes remain unchanged. Alternative link uses that yield identical aggregate link volumes can affect O-D specific estimates of fuel consumption, pollution emissions or development impacts. Equilibrium assignments found by methods of linear combinations, such as the Frank-Wolfe algorithm, may not represent most likely link uses. The problem of finding maximum entropy link uses (MELU) formulated herein is a multi-commodity optimum flow (max-flow at min-cost) problem with nonlinear flow-dependent link use costs. MELU does not require path enumeration or knowledge of used paths between zones, but it is NP-hard to solve and very sizable for large networks. An approximate solution technique is presented that finds likely link uses for realistic size problems. The method is to linearly combine successive F-W solutions using step sizes that seek a maximum entropy mix. The examples include other comparisons of trial link uses that indicate the extent to which they differ.


Dynamic traffic assignment and observed traffic counts are used to estimate the distribution of departure times in an urban area trip matrix. The objective is to find the maximum entropy distribution of departure times by origin zone subject to observed traffic counts on a subset of network links. The procedure results in the estimated number of trip departures from each origin in 10-15 minute time intervals of the full analysis period. Such an analysis period will typically range from one to three hours long. We first review the dynamic user-equilibrium assignment problem (DUE) and the dynamic traffic assignment algorithm (DTA) from a previous paper, and then describe its use with traffic counts to estimate departure times in a trip matrix. We present an application to a Pittsburgh network in which trip departures are estimated for each 10 minute interval of a peak-hour survey trip matrix. Dynamic assignment and departure time estimation based on traffic counts can be used to examine the impacts of alternative transportation management strategies such as work hour changes and ramp metering. Computational advances such as parallel computing will enable the procedure to be run on large networks while counts are being monitored. Such an application may provide near real-time detection of temporal trip departure profiles by origin zone in emergency evacuations or other special events.


This paper presents a nonlinear programming formulation of the dynamic user-equilibrium assignment problem (DUE) for urban road networks with multiple trip origins and destinations. DUE is a temporal generalization of the static user-equilibrium assignment problem (SUE) with additional constraints to insure temporally continuous paths of flow. In DUE, the full assignment period of several hours is discretized into shorter time intervals of 10-15 minutes each for which trip departure matrices are assumed to be known. This
formulation of DUE includes SUE as a special case in which there is only one time interval for the full assignment period. The assumption of steady-state flows allows SUE to have all linear constraints, but DUE requires nonlinear flow continuity constraints. Whereas SUE is typically solved by methods of linear combinations, these methods create temporally discontinuous flows if applied to DUE. A dynamic traffic assignment heuristic (DTA) is presented that generates approximate solutions to DUE in an efficient manner for large networks. DTA is not a convergent solution algorithm for DUE, but was designed instead to produce assignments that approximate the DUE optimality conditions. An overview of alternative dynamic assignment approaches is given, including the limitations of other optimization and simulation approaches. Test results presented in this paper show that DTA generates both static and dynamic assignments that approximately satisfy the user-equilibrium conditions of these problems.


AB This paper describes network modelling of travel guidance impacts using combined dynamic distribution and assignment (CDDA) in which a subset of area motorists are provided real-time directives as to destination, route, and departure time decisions. Examples illustrate potential magnitudes of system-wide impacts, including travel time and fuel consumption, achieved by different percentages of motorists given directives aimed at improving user equilibrium conditions. Travel guidance regarding modal choice is not included in this paper, although that extension is similar to other network models. Results are given for a Pittsburgh network in which freeway lanes are partially blocked during rush hour due to a truck accident. Indications are that significant reductions in system-wide impacts can be achieved by guiding a subset of area motorists to specific travel choices based on real-time information. Future research issues are types, amounts, and locations of real-time data needed to provide reliable travel guidance, and the relative impacts of in-vehicle versus point-of-departure travel guidance systems.


AB Traditional (static) network equilibrium models have always been formulated in a route-based fashion rather than a vehicle-based fashion. That is, the decision variables have been the number of vehicles using each route rather than the route choices of each vehicle. Given the success of this approach, it is not surprising that recent "dynamic" network equilibrium models have been formulated in a similar way. That is, the decision variables in these models are usually the route-specific departure rates over time. In this paper, we develop a vehicle-based equilibrium model of simultaneous route and departure-time choice and discuss the possible advantages of this approach. We then describe a heuristic for serving this model and demonstrate its effectiveness on several small examples.


AB Two critical aspects related to microscopic simulation are discussed: a methodology for calibration and validation, and the integration of path dynamics modeling on large networks. These are among the most significant challenges in microscopic simulation for decision support and analysis in advanced traffic management and information systems. For calibration and validation, a distinction is made between conceptual and operational phases; the conceptual phase concerns the basic models such as car following and lane changing, and the operational phase is associated with the context of the study (origin-destination, parameters adjustments with respect to the network under study, etc.). Then a methodology is described that brings to microscopic simulation the type of capabilities for path processing and storage normally found only with macroscopic models, often because the network representation is less detailed for those. This is based on a hybrid simulation approach. An example of integrating the parallel microscopic simulation with the routing and behavior response simulation schemes, as in the dynamic network assignment simulation model for the
advanced road telematics macroscopic model, is used to explain a candidate methodology to enhance microscopic models for evaluating information-routing schemes in advanced traffic management and information systems. Relevant problems faced by advanced traffic management and information systems modelers are raised that are worth further discussion; the intention is not to provide extensive results or even to answer all of the questions raised.


AB This paper is an extension of earlier work on dynamic traffic assignment with an analytically embedded traffic flow simulation. Previously, a modified Greenshields' speed-density relationship was used to derive a link travel time function that is monotonically increasing and convex with respect to density. It was recognized that this link travel time function is more applicable for freeway traffic than for arterial street traffic, where a large portion of travel times occurs at the nodes as a result of queueing. In this paper a version of the model is developed with explicit queueing links to simulate such traffic conditions on an arterial street network. The dynamic traffic assignment problem is formulated in a two-level optimization framework, separating the temporal and spatial variables into two problems. The lower-level problem represents an equilibrium traffic assignment model that solves the spatial variables subject to a set of feasible paths fixed by the temporal estimates from the upper-level problem. The upper-level problem determines the temporal variables by finding the minimum time-dependent travel times from the origin to all other nodes, assuming equilibrium traffic loads assigned from the previous lower-level problem to be fixed. A set of recursive equations is derived to compute the link traversal times that satisfy the first-in, first-out requirement. An iterative solution algorithm using small time steps with queueing links is developed to solve the proposed two-level dynamic traffic assignment problem. Results are also provided to show the effects of embedding a traffic simulation with explicit treatment of queues to capture traffic dynamics on arterial streets.


AB Conventional traffic assignment methods assume that the origin-destination (OD) demand is uniformly distributed over time to estimate the traffic pattern. This assumption does not hold for modeling peak periods of congestion in which the OD demand is time varying. In this paper, we present a dynamic traffic assignment model with traffic-flow relationships based on a bi-level optimization framework. Our assignment variable is the number of vehicles present on a link during a time step, rather than traffic flow, which is used in static assignment. Using the modified Greenshields speed-density relationship, we derive a link-cost function that is monotonically nondecreasing and convex with respect to density. To capture traffic dynamics, we use short time-steps. The model prevents violations of the first-in-first-out (FIFO) condition using constraints on the distances moved by vehicles during each time step. A solution algorithm which resembles a Stackelberg leader-follower problem is presented, and numerical results from networks of different sizes demonstrate that the proposed model performs satisfactorily.


AB A model combining traffic simulation and path assignment capabilities is presented to analyze the effect of in-vehicle real-time information on the performance of a congested traffic network. The research integrates the main components of a traffic network under real-time information, namely, the traffic flow, the driver behavior, and the network information dissemination, into a single modeling framework which is then used to study the underlying dynamics and evaluate alternative designs of such traffic systems. Drivers' route decisions in response to the information are modeled individually at each node. Results of a series of simulation experiments are discussed. Special coding considerations for efficient vector processing on supercomputers are also examined.
A Bayesian updating model is developed to capture the mechanism by which travelers update their travel time perceptions from one day to the next in light of information provided by Advanced Traveler Information Systems (ATIS) and their previous experience. The availability and perceived quality of traffic information are explicitly modeled within the proposed framework. The uncertainty associated with a driver's travel time estimate is modeled in a stochastic dynamic framework and is incorporated in a travel choice model. Each driver uses a disutility function of perceived travel time and perceived schedule delay to evaluate the alternative travel choices, then selects an alternative based on the utility maximization principle. The perception updating model and the choice model are integrated with a dynamic traffic simulator (DYNASMART). Empirical results from the simulation experiments and their implications are also presented.

There are many applications of queuing theory in traffic flow analysis, especially in traffic signal control and dynamic traffic assignment. It is proved to be appropriate to describe the traffic performance by using the queue model. In this paper we first summarize how the queuing models are useful at signalized junctions. Then we use the vertical queuing method to analyze the dynamic queuing process of vehicles. We will focus on the travel time from entrance to exit in the link and give a new expression for delay which will be divided into four parts, the stopping loss, starting loss, discharging time and stopping time. The detail calculating formulas for each part will be presented.

The objective of this paper is to investigate the impact of pre-trip information on auto commuters' choice behavior. The analysis is based on an extensive home-interview survey of commuters in the Taichung metropolitan area in Taiwan. A joint model for route and departure time decisions with and without pre-trip information is formulated. The model specifications are developed for both the systematic and random components. In particular, econometric issues associated with specifying the random error structure are addressed for parameter estimation purposes. Insights into the effects of attributes are obtained through the analysis of the model's performance and estimated parameter values. A probit model form is used for the joint model, allowing the introduction of state dependence and correlation in the model specification. The results underscore the important relationship between the different characteristics and the propensity of commuter choice behavior under two scenarios, with and without pre-trip information.

In recent years, traffic congestion in transportation networks has grown rapidly and has become an acute problem. The impetus for studying this problem has been further strengthened due to the fast growing field of Intelligent Vehicle Highway Systems (IVHS). Therefore, it is critical to investigate and understand the nature of traffic congestion and address questions of the type: how are traffic patterns formed? and how can traffic congestion be alleviated? Understanding drivers' travel times is key behind this problem. In this paper, we present macroscopic models for determining analytical forms for travel times. We take a fluid dynamics approach by noticing that traffic macroscopically behaves like a fluid. Our contributions in this work are the following: (i) We propose two second-order non-separable macroscopic models for analytically estimating travel time functions: the Polynomial Travel Time (PTT) Model and the Exponential Travel Time (ETT) Model. These models generalize the models proposed by Kachani and Perakis [3] as they incorporate second-order effects such as reaction of drivers to upstream and downstream congestion as well as second-order link
interaction effects. (ii) Based on piecewise linear and piecewise quadratic approximations of the departure flow rates, we propose different classes of travel time functions for the first-order separable PTT and ETT models, and present the relationship between these functions. (iii) We show how the analysis of the first-order separable PTT Model extends to the second-order model with non-separable velocity functions for acyclic networks. (iv) Finally, we analyze the second-order separable ETT model where the queue propagation term -corresponding to the reaction of drivers to upstream congestion or decongestion- is not neglected. We are able to reduce the analysis to a Burgers equation and then to the more tractable heat equation.


AB In this paper, the Dynamic Traffic Routing problem is defined as the real-time point diversion of traffic during non-recurrent congestion. This dynamic traffic routing problem is then formulated as a feedback control problem that determines the time-dependent split parameters at the diversion point for routing the incoming traffic flow onto the alternate routes in order to achieve a user-equilibrium traffic pattern. Feedback linearization technique is used to solve this specific user-equilibrium formulation of the Dynamic Traffic Routing problem. The control input is the traffic split factor at the diversion point. By transforming the dynamics of the system into canonical form, a control law is obtained which cancels the nonlinearities of the system. Simulation results show that the performance of this controller on a test network is quite promising.


AB This paper formulates the Dynamic Traffic Routing (DTR) problem as a real-time feedback control problem. Three different forms of the formulation are presented: (1) distributed parameter system form derived from the conservation law; (2) space discretized continuous lumped parameter form; (3) space and time discretized lumped parameter form. These formulations can be considered as the starting points for development of feedback control laws for the different control problems stated in this paper. This paper presents the feedback control problems, and does not discuss in detail the methodology of solution techniques which could be used to solve these problems. However, for the sake of completeness a brief treatment of the three forms are included in this paper to show possible ways to design the controllers.


AB A new method for performing Dynamic Traffic Assignment (DTA) is presented which is applicable in real time, since the solution is based on feedback control. This method employs the design of nonlinear H_oo feedback control systems which is robust to certain class of uncertainties in the system. The solution aims at achieving user equilibrium on alternate routes in a network setting.


AB This paper presents a solution to the user equilibrium Dynamic Traffic Routing (DTR) problem for a point diversion case using feedback control methodology. The sliding mode control technique which is a robust control methodology applicable to nonlinear systems in canonical form is employed to solve the user equilibrium DTR problem. The canonical form for this problem is obtained by using feedback linearization technique, and the uncertainties of the system are countered by using sliding mode principle. Simulation results show promising results.

The formulation of a system dynamics model for the dynamic traffic routing (DTR) problem is addressed, specifically for the application of real-time feedback control. Also addressed is the design of fuzzy feedback control laws for this problem. Fuzzy feedback control is suitable for solving the DTR problem, which is nonlinear and time varying and contains uncertainties. To illustrate the applicability of fuzzy logic in the design of feedback control for DTR, a simple software simulation was conducted that provided encouraging results.


Multistage stochastic programming problems can be introduced as a finite system of parametric (one-stage) optimization problems with an inner type of dependence. Employing this dependence we analyse the relationship between one-stage and multistage stochastic programming problems. Furthermore, we introduce some stability and empirical estimates results in the special case of stochastic dependence.


This paper considers the problem of dynamic traffic assignment under the principle that individual drivers will choose fastest paths, in the dynamic situation where path durations consist of time-dependent link travel times. Rather than constructing a unified model encompassing traffic dynamics and route choice, we decompose the model into an assignment mapping, which identifies the link travel times resulting from an input routing policy, and a routing mapping, which yields fastest-path routings associated with input link travel times. Since time-dynamic link travel times are influenced by route choice, this dynamic situation therefore encompasses predictive routing strategies. We establish that user-equilibrium routing policies are fixed points of the composition of the routing and assignment functions. After discussing difficulties associated with establishing existence of fixed points under discrete-time modeling and all-or-nothing routing, we present instead new iterative routing mappings for continuous-time multipath routing (the splitting of a single-class flow onto multiple paths), which adjust routing policies more incrementally. We provide sufficient conditions for existence of fixed points in various routing policy domains and offer some suggestions on the computation of these fixed-point policies.


One of the major challenges facing ITS (Intelligent Transportation Systems) today is to offer route guidance to vehicular traffic so as to reduce trip time experienced. In a cooperative route guidance system, the problem becomes one of assigning routes to vehicles departing at given times from a set of origins to a set of destinations so as to minimize the average trip time experienced (a so-called system optimal criterion). Since the time to traverse a link will depend upon traffic volume encountered on that link, link times are dynamic. The complex interaction resulting between objective function and constraints makes the dynamic problem significantly more difficult to formulate and solve than the static version. We present a mixed integer linear programming formulation of the problem which is formally derived from a set of traffic flow assumptions. Principal among these is the simplifying assumption that vehicles upon entering a link, assume the speed that traffic would attain were the traffic volume encountered on that link in steady-state. The integer variables correspond to selection of vehicle capacity constraints on the link while the continuous variables correspond to selection of vehicle routes. Implicit within this MILP formulation of the dynamic traffic assignment problem is therefore a decomposition of the problem which results in a conventional capacitated linear programming network flow problem. A small illustrative subnetwork extracted from the city of Sioux Falls is solved to optimality by IBM's OSL Branch-and-Bound algorithm.

**AB** Most of the previous dynamic traffic assignment models are Limited to single destination networks. The reason is that link exit functions of multiple destination flows are not formulated correctly. Since link exit functions of multiple destination flows have been formulated by Liu and Kawakami (1993), the previous dynamic traffic assignment models can be improved from many aspects by the aid of the link exit function. In this paper, the constraint set of the dynamic traffic assignment problem is qualified first. The qualified constraint set can be applied to any dynamic traffic assignment problem. Then a continuous dynamic system optimum model and a discrete dynamic system optimum model are presented. The model can be applied to dynamic traffic assignment for multiple destination networks. Furthermore, an algorithm is developed to solve the discrete model. Test examples show that the algorithm can solve the discrete model efficiently.


**AB** Methods of performing dynamic traffic assignment are needed to simulate traffic conditions on urban highways during peak periods of congestion. In this paper, the route choice behavior and two kinds of dynamic user optimum are analyzed first, then the constrains for dynamic traffic assignment problem are formulated. Finally, a practical simulation method is developed to perform dynamic traffic assignment for urban road network.


**AB** In this paper we consider two traffic control strategies relying on user response to information and/or flow restriction. Ultimately, the control strategies are designed to function in real time, hence provide command values based on actual conditions and requiring little computational effort. The proposed control strategies are based on the idea that the network load, as measured by instantaneous travel times for instance, should be shared as equally as possible between paths. In order to achieve such an aim, the commands are designed to make the system state converge towards a state in which instantaneous travel times of paths relative to any given OD tend to be equal.

Kimber, R. M.; Hollis, Erica M. (1979) Traffic queues and delays at road junctions. TRRL Laboratory Report (Transport and Road Research Laboratory, Great Britain), n 909.

**AB** Methods are described for the prediction of queue lengths and vehicular delays at road junctions subject to time-varying traffic demand and capacity. The properties of individual traffic streams are developed firstly in terms of the probability distribution of queue lengths, and secondly by approximation formulae which allow queues and delays to be predicted directly. Two approaches are used: a high-definition representation in which the queue length is developed in a sequence of small consecutive time intervals, and a low-definition representation which allows the overall delay for a peak period to be predicted given traffic flows averaged over a longer period.


**AB** This article estimates and evaluates the economic impacts from a catastrophic earthquake within regional and national contexts, emphasising the inter-industry relationship ill Conjunction with regional commodity flows and the assessment of seismic damages oil a transportation network. The analytical methods employed are twofold: a multi-regional input-output model and a regional commodity How model. Using the above analytical framework, the economic impacts from a catastrophic earthquake are estimated and evaluated based oil hypothetical scenarios of the event. by analysing the magnitude and extent of direct and indirect impacts.
Furthermore, as possible extensions, the models developed here can be used as tools for strategic management of the recovery and reconstruction efforts after the event.


AB Motivated by applications in road traffic control, we study flows in networks featuring special characteristics. In contrast to classical static flow problems, time plays a decisive role. Firstly, there are transit times on the arcs of the network which specify the amount of time it takes for flow to travel through a particular arc; more precisely, flow values on arcs may change over time. Secondly, the transit time of an arc varies with the current amount of flow using this arc. Especially the latter feature is crucial for various real-life applications of flows over time; yet, it dramatically increases the degree of difficulty of the resulting optimization problems. Most problems dealing with flows over time and constant transit times can be translated to static flow problems in time-expanded networks. We develop an alternative time-expanded network with flow-dependent transit times to which the whole algorithmic toolbox developed for static flows can be applied. Although this approach does not entirely capture the behavior of flows over time with flow-dependent transit times, we present approximation results which provide evidence of its surprising quality.


AB The problem of designing integrated traffic control strategies for motorway networks with the use of ramp metering, route guidance, and motorway-to-motorway control measures is considered in this paper. A generic problem formulation is presented in the format of a discrete-time optimal control problem whose numerical solution is achieved by use of a feasible-direction algorithm. As an illustrative example, a relatively simple motorway network is considered under different control scenarios. In each case the optimal control strategy is discussed along with its effect on the traffic flow process. The results demonstrate the efficiency of the proposed approach as well as the genuinely intelligent behaviour of the designed control strategy.


AB With a dynamic traffic assignment model real-time control algorithms are derived for an alternative route guidance system. As traffic model a fluid dynamic description of traffic flow is presented which uses a specific speed density relation and an anticipation of traffic conditions downstream. The macroscopic traffic flow model is solved numerically with initial and boundary conditions including links and modes derived from actual measurements and with data for compliance rates of alternative route indications via variable message signs. For three actual alternative route guidance systems in Germany, the application of the real-time control algorithms is demonstrated. From these examples data are gathered, compliance rates are derived and the advantages for different traffic situations of the alternative routing strategy are presented.


AB A modelling framework based on microscopic computer simulations and representing day-to-day and within-day dynamic and stochastic processes in urban traffic networks is being developed. It combines a detailed representation of individual drivers' choice and learning behaviour as this evolves within and between days, with a detailed traffic simulation of individual vehicles. The framework as a research tool has been applied to a number of networks to study the effect of variability in travel demand and network conditions upon system performance, and of variability in driver behaviour on route choice.

AB This paper presents the development of a GIS application to conduct a dynamic transportation network analysis. This application was based on numerous efficient routing modules developed by the authors in C++ and MapBasic, the development environment of MapInfo. Additionally, a methodology for implementing the simulation-based DTA model in a GIS environment is presented. This methodology includes building a spatial transportation database with a set of specific sophisticated data models and integrating the simulation-based DTA model with the GIS system (DTA-GIS system). Finally, an application of the simulation-based DTA model is demonstrated in a case study using the street network in City of Lawrence, Kansas.


AB This research extends the dynamic user optimal assignment under the point queue concept so as to deal with physical queues. Given time-dependent many-to-many OD volumes, this paper first shows the formulation of the assignment subject to the how conservation and the first-in-first-out (FIFO) queue discipline. The optimal condition is then defined and the physical queue propagation based on the kinematic wave theory is discussed. Finally, a solution algorithm is proposed and typical differences between point and physical queue analyses are presented through an example calculation.


AB This research discusses the formulation and solution algorithm of the reactive dynamic traffic assignment with the link travel time explicitly taking into account the effects of queues under the point queue concept. In the reactive assignment, vehicles are assumed to choose their routes based on present instantaneous travel times. Time dependent many-to-many origin-destination volumes are assumed to be given; that is, the departure times of vehicles from origins are known. We first discuss the formulation of the dynamic assignment so as to satisfy the flow conservation and the First-In-First-Out queue discipline. Then, the reactive assignment is shown to be decomposed with respect to present time, since route choices of Vehicles are dependent on the present traffic situation but independent of the past and future traffic condition. An algorithm is finally proposed based upon the decomposition.


AB We propose a new mathematical formulation for the problem of optimal traffic assignment in dynamic networks with multiple origins and destinations. This problem is motivated by route guidance issues that arise in an Intelligent Vehicle-Highway Systems (IVHS) environment. We assume that the network is subject to known time-varying demands for travel between its origins and destinations during a given time horizon. The objective is to assign the vehicles to links over time so as to minimize the total travel time experienced by all the vehicles using the network. We model the traffic network over the time horizon as a discrete-time dynamical system. The system state at each time instant is defined in a way that, without loss of optimality, avoids complete microscopic detail by grouping vehicles into platoons irrespective of origin node and time of entry to network. Moreover, the formulation contains no explicit path enumeration. The state transition function can model link travel times by either impedance functions, link outflow functions, or by a combination of both. Two versions (with different boundary conditions) of the problem of optimal traffic assignment are studied in the context of this model. These optimization problems are optimal control problems for nonlinear discrete-time dynamical systems, and thus they are amenable to algorithmic solutions based on dynamic programming. The computational challenges associated with the exact solution of these problems are discussed and some heuristics are proposed.

**AB** We consider a traffic network subject to known time-varying demands between its origins and destinations. We model the network as a discrete-time dynamical system driven by these demands. The state of the system at each time epoch is defined in a way that avoids complete microscopic detail by grouping vehicles into platoons irrespective of origin node and time of entry to network. Moreover, the formulation contains no path enumeration. The control variables correspond to the assignment or routing of the platoons on downstream links at the nodes of the network. Impedance functions combined with link outflow functions are used to model link travel times in the state transition function. This modeling approach allows for the study of the problem of dynamic traffic assignment in networks in the framework of the optimal control of dynamical systems. This work has applications to route guidance issues that arise in an Intelligent Vehicle-Highway Systems (IVHS) environment.


**AB** This research develops a theoretical model to analyze commuters' joint decisions of route and departure time in a simple network with two parallel routes: one with free but congested lanes, the other with free-flowing tolled lanes with time-varying tolls. By accounting for trip distance, the theoretical model is able to examine the two different sources of travel time uncertainties: length of commute and type of route. Length of commute causes long-distance commuters to leave home earlier, but type of route may lead to a change of route as well as of departure time to compensate for the higher risk of arriving late for work. Results show that long-distance commuters are less likely to take toll lanes than people with short commutes; that travelers who plan to take toll lanes are unlikely to switch to free lanes en route because their later departure times reflect the savings and reduced uncertainty in travel time; and that provision of pretrip information favors the use of toll lanes and may result in commuters leaving home later, even in heavier-than-normal traffic. The theoretical model provides more flexible demand specification for simulation studies. In addition it has important policy implications because it allows a better understanding of commuters' travel behaviors on roads with value-pricing schemes, such as the express lanes on CA-91 and high-occupancy toll lanes on I-15 in California.


**AB** This paper presents a combined activity/travel choice model and proposes a flow-swapping method for obtaining the model's dynamic user equilibrium solution on congested road network with queues. The activities of individuals are characterized by given temporal utility profiles. Three typical activities, which can be observed in morning peak period, namely at-home activity, non-work activity on the way from home to workplace and work-purpose activity, will be considered in the model. The former two activities always occur together with the third obligatory activity. These three activities constitute typical activity/travel patterns in time-space dimension. At the equilibrium, each combined activity/travel pattern, in terms of chosen location/route/departure time, should have identical generalized disutility (or utility) experienced actually. This equilibrium can be expressed as a discrete-time, finite-dimensional variational inequality formulation and then converted to an equivalent "zero-extreme value" minimization problem. An algorithm, which iteratively adjusts the non-work activity location, corresponding route and departure time choices to reach an extreme point of the minimization problem, is proposed. A numerical example with a capacity constrained network is used to illustrate the performance of the proposed model and solution algorithm.


**AB** This paper presents a conceptual activity-based and time-dependent traffic assignment model. The temporal utility profiles of activities are employed to formulate the temporal activity choice behavior of individuals as a multinominal legit model. Route choice behavior is then described as the ideal dynamic user
equilibrium condition. The combined activity/route choice condition is formulated as a time-dependent variational inequality problem, which is solved by a heuristic solution algorithm based on the space-time expanded networks.


AB In view of the serious traffic congestion during peak hours in most metropolitan areas around the world and recent improvement of information technology, there is a growing aspiration to alleviate road congestion by applications of electronic information and communication technology. Providing drivers with dynamic travel time information such as estimated journey times on major routes should help drivers to select better routes and guide them to utilize existing expressway network. This can be regarded as one possible strategy for effective traffic management. This paper aims to investigate the effects and benefits of providing dynamic travel time information to drivers via variable message signs at the expressway network. In order to assess the effects of the dynamic driver information system with making use of the variable message signs, a time-dependent traffic assignment model is proposed. A numerical example is used to illustrate the effects of the dynamic travel time information via variable message signs.


AB A multiperiod time-dependent model for departure time and route choices in networks with residual queues is presented. The proposed model is meant to be used for strategic transportation planning, taking into account the effects of time-dependent queues that are carried over to the next period. The departure time choice is based on an incremental logit model, whereas the route choice follows an extended user equilibrium (UE) principle. This model is formulated as the variational inequality (VI) problem, which accounts for the major features of networks with residual queues, including the effects of queue delay and traffic flow truncation due to road exit capacity. The Jacobi method is used to solve the VI problem. In the proposed solution method, the diagonalization subproblem is equivalent to the steady state extended UE assignment for networks with queues. A simple numerical example is used to illustrate the application of the solution method.


AB A freeway or expressway corridor where all vehicles travel to the same destination such as the city centre is considered in this article, similar to the morning commute problem. A continuous time optimal control model that deals with the dynamic user optimal assignment for multiple origins and single destination is proposed. The splitting rates of traffic flows at each network node are defined as the control variables in this model. The optimality conditions are proved to be equivalent to the dynamic user optimal principle or user equilibrium of instantaneous travel cost. In order not to solve the complicated two-point boundary-value problem with substantial computational times for obtaining the optimal control solution, a steady state-costate solution algorithm is developed that generates an approximate solution to the network optimal control problem. This algorithm exploits advantage of the embedded network structure of the problem and would be computationally efficient. A numerical example with two peak period traffic demands which was drawn from the road network problem between Hong Kong and several adjacent cities of inland China is used to demonstrate the performance of the proposed algorithm.


AB In previous real-time flow prediction studies, the emphasis was placed on the prediction accuracy of the model. The accuracy of the prediction bounds (or limits), on the other hand, was largely ignored. Prediction bounds are, however, important input parameters in such applications as real-time stochastic traffic control,
incident detection, and route guidance in the context of dynamic traffic assignment. The objectives of this study are to explore the statistical nature of traffic flows when aggregated at short time intervals and to examine the potential of using the generalized linear model in the dynamic setting to predict traffic flows and provide prediction bounds. Specifically, this study derives recursive algorithms based on the quasi-likelihood principle and performs on-line, multiple-step-ahead predictions of short-term arrival flows for signalized intersections. Preliminary results are presented using a simulated data set from CORSIM and a real data set collected from signalized intersections.


The purpose of the paper is to adapt the classical LWR (Lighthill-Whitham-Richards) model, in its continuous version, to networks, in the context of dynamic assignment. This implies several specific adaptations of the basic model: introduction of partial flows, possibly inhomogeneous flows on links, and intersection modeling. The latter proves particularly difficult, and we discuss three different modeling approaches: extended versus pointwise intersection models, and flow maximization. We show that all three types of models are actually closely related, and compatible with the link flow models. The concepts of local traffic supply and demand prove to be essential, both for link and for intersection modeling. A brief comparison with experimental merge data gives some support to the phenomenological models introduced in the paper.


This paper is concerned with the problem of on-line monitoring of a traffic network. The problem was motivated by the need of real-time dynamic traffic assignment systems to maintain an internal representation of the traffic network consistent with that of the actual network. Potential error sources that can cause inconsistencies between the internal and the actual state of the network are identified and classified. The issues of observability and state variable definition of traffic networks are discussed. A framework for a monitoring system is sketched that aims to maintain a representation of the state of a network consistent with that of the actual network by applying on-line and off-line adjustments. Some solution approaches and computational results are presented for the main modules of the framework.


An analytical-based dynamic traffic assignment (DTA) model intended for off-line analysis and evaluation of non-recurring lane-blocking events is proposed. Formulated as a variational inequality (VI), this model solves an ideal dynamic user-optimal (DUO) route choice problem. A diagonalization algorithm is proposed to solve the model to a prespecified convergence using a large-scale, real-life traffic network. Adjustments of link capacities triggered by external lane-blocking events and internal modeled traffic phenomena are explicitly considered in the solution algorithm to capture queue formation and dissipation. The proposed solution procedure approximates route choices based on anticipatory and non-anticipatory traffic conditions to account for potential enroute diversions caused by non-recurrent lane-blocking events. Model implementations, computational results, and conclusions are presented and discussed. The proposed model, solution procedure, and associated features demonstrate capabilities for realistic network-wide applications with ATMIS implications.


The report describes a computer-based traffic assignment and queueing model for use in the design of urban traffic management schemes. The model is called CONTRAM EM DASH CONtinuous TRaffic Assignment Model. CONTRAM requires data on time-varying flow demands and predicts the flows, delays
and queues throughout a network of roads and junctions. The movement of traffic is modeled by grouping vehicles together to form 'packets'. Each packet is assigned to its minimum journey time route through the network, taking into account delays and queues at junctions.


AB A discrete time reactive dynamic user equilibrium (DUE) model for network with queues is presented. Based on the point queue model, each link is assumed to have a constant running time and queuing delay caused by link exit capacity. The link performance function and link exit function are given as functions of the arrival rate and the queue length, where the first-in-first-out (FIFO) rule is shown to be satisfied. The DUE problem is then formulated as a variational inequality (VI) problem over a polyhedral set by constructing a new network so that the path enumeration is avoided. Therefore the proposed model is applicable for large-scale networks. The existence of solution for VI problem is proved, and an iteration method is discussed in detail. A static capacity constrained model is employed to initialize the network and avoid the zero-flow network at initial time. Finally, the advantages of the new model and method proposed are tested by numerical examples.


AB A combined model for time-dependent trip distribution and traffic assignment is proposed. The model assumes known time-dependent departure rates from origins and overall arrival rates at destinations, and it then seeks to estimate the origin-destination matrix according to the observed entropy value and to minimize the total system travel time. A solution algorithm is proposed based on the Dantzig-Wolfe decomposition principle and a Lagrangian relaxation approach. Computational results on a test network are also presented and discussed.


AB The system optimum dynamic traffic assignment problem, in which drivers fix their arrival rather than their departure times, is examined. A model is formulated as a linear program that simultaneously optimizes departure time and route choice. The model applies to multiorigin/destination problems, and the first-in-first-out condition is generally observed on the links and nodes of the network. An extension is discussed that accounts for combined departure time- and arrival time-based demand on the same network. The models are tested on an example network, and the results are discussed.


AB This paper investigates the existence, uniqueness, and global exponential stability (GES) of the equilibrium point for a large class of neural networks with globally Lipschitz continuous activations including the widely used sigmoidal activations and the piecewise linear activations. The provided sufficient condition for GES is mild and some conditions easily examined in practice are also presented. The GES of neural networks in the case of locally Lipschitz continuous activations is also obtained under an appropriate condition. The analysis results given in the paper extend substantially the existing relevant stability results in the literature, and therefore expand significantly the application range of neural networks in solving optimization problems. As a demonstration, we apply the obtained analysis results to the design of a recurrent neural network (RNN) for solving the linear variational inequality problem (VIP) defined on any nonempty and closed box set, which includes the box constrained quadratic programming and the linear complementarity problem as the special cases. It can be inferred that the linear VIP has a unique solution for the class of Lyapunov
diagonally stable matrices, and that the synthesized RNN is globally exponentially convergent to the unique solution. Some illustrative simulation examples are also given.


Lin, WH, Lo, HK (2000) Are the objective and solutions of dynamic user-equilibrium models always consistent? Transportation Research 34A, 137-144.

AB Existing dynamic user-equilibrium traffic assignment (DUETA) models are mostly expanded from the static user-equilibrium traffic assignment model by introducing the time dimension along with a group of additional constraints. Whereas the equivalency between the solution to the traffic assignment model and the user-equilibrium condition as defined by Wardrop is well established in the static case, the same may not be true for the dynamic case. This paper examines the general form of DUETA models as proposed in previous research and shows that, if queuing behavior is represented in the model at a minimal level, the solution to conventional DUETA models with an objective function of the form adopted by most existing formulations may not necessarily converge to or approximate the Wardropian user-equilibrium condition in the dynamic sense as defined by many researchers.


AB An improved high-order continuum model is developed based on hyperbolic conservation laws with relaxation, linearized stability analysis, and more realistic considerations of traffic flow. The improved high-order model allows smooth traveling wave solutions as well as contact shocks (different densities moving at the same speed), is able to describe the amplification of small disturbances on heavy traffic, and allows fluctuations of speed around the equilibrium values. Furthermore, unlike existing high-order models, it does not result in negative speeds at the tail of congested regions and disturbance propagation speeds greater than the traffic flow velocity because the improved model has a zero characteristic speed and a nonnegative characteristic speed that is equal to the traffic flow velocity. The relaxation time is a function of density and, in the equilibrium limit, the improved high-order model is consistent with the simple continuum model. The improved high-order model is compared with the simple continuum model. Exemplary test results suggest that the improved high-order model is intuitively correct. Comparison of numerical results with field data suggests that the improved high-order model yields lower error levels than the simple continuum model.


AB Traffic assignment has received much attention since 1950's. Stochasticity, dynamic and fuzziness are three characteristics of traffic assignment. Since drivers always have no perfect information about traffic conditions, they choose their route based on perceived travel time. Traditional traffic assignment model can only capture the stochasticity and dynamic features of traffic assignment and cannot represent the fuzziness of driver's perception over travel time. Thus, we present a fuzzy dynamic traffic assignment (FDTA) model in this paper. By the definition of fuzzy perceived link travel time and fuzzy perceived path travel time, we use fuzzy shortest path algorithm to find the group of fuzzy shortest paths and assign traffic to each of them proportionally to their memberships. The proposed FDTA model can be used in the real-time network load management, especially with variable message signs.

AB Dynamic traffic assignment (DTA) has been a topic of substantial research during the past decade. Although DTA is gradually maturing, many aspects still need improvement, especially regarding its formulation and solution capabilities under the transportation environment affected by advanced transportation management and information systems. It is necessary to develop a set of DTA models to acknowledge the fact that the traffic network itself is probabilistic and uncertain, and different classes of travelers respond differently under an uncertain environment given different levels of traffic information. The aim of this research is to advance the state of the art in DTA modeling in the sense that the proposed model captures the travelers' decision making among discrete choices in a probabilistic and uncertain environment, in which both probabilistic travel times and random perception errors that are specific to individual travelers are considered. Travelers' route choices are assumed to be made with the objective of minimizing perceived disutilities at each time. These perceived disutilities depend on the distribution of the variable route travel times, the distribution of individual perception errors, and the individual traveler's risk-taking nature at each time instant. The integrated DTA model is formulated through a variational inequality approach. Subsequently, the solution algorithm for the formulation is discussed, and experimental results are given to verify the correctness of solutions obtained.


AB Previous work on the effect of advanced traveler information systems was concerned primarily with immediate route choice decisions in response to real-time traffic information. Real-time traffic information also influences day-to-day decisions of trip makers, including departure time and route choices. Joint departure time decision and pretrip route selection are addressed, as well as en route path switching behavior by commuters under real-time information availability. Data were used from laboratory experiments using a dynamic interactive traveler simulator that allows actual commuters to simultaneously interact with each other within a simulated traffic corridor. Given real-time information provided by the system, commuters determine their departure time and route at the origin and select paths en route at various decision nodes along the trip. Day-to-day dynamic models of commuters' joint departure time and route switching decisions are developed and calibrated by using a multinomial probit model framework that takes into account commuters' learning from experience. The analysis provides insight into day-to-day effects of real-time traffic information on we'er decisions. Results indicate that the reliability of real-time information and supplied schedule delay (relative to the commuters' preferred arrival time) are significant variables that influence users' indifference band governing route switching behavior both pretrip and en route. These models are intended for use within evaluation frameworks (e.g., simulation-assignment models). In addition, the substantive insights provide guidelines for the design of real-time information content and systems.


This study developed a dynamic traffic control system designated as Dynamic Intersection Signal Control Optimization (DISCO). DISCO considers the entire Fundamental Diagram of traffic flow, which is essential for controlling congested and transient traffic. As a dynamic model, DISCO works with time-variant traffic patterns and derives dynamic adaptive timing plans. In this study, we applied DISCO to a congested network in Hong Kong and compared the performance of various control strategies enabled by DISCO. The results showed that DISCO outperformed the existing plans by more than 50% in terms of overall delay reduction. Moreover, DISCO performed best under the most flexible control scheme of "variable green no cycle" strategy. DISCO shows promise as a new approach for demand-responsive traffic control.


Recent advances in traffic control methods have led to flexible control strategies for use in an adaptive traffic control system (ATCS). ATCS aims at controlling the imminent traffic, which is yet to arrive and hence not known perfectly. Therefore, volume prediction is an essential part. Associated with the prediction are two aspects: resolution and accuracy. Recent studies indicate a tradeoff between prediction resolution and accuracy: finer resolutions, larger errors. It is imperative to study the relationship and tradeoff between the control strategy, prediction resolution, and its associated error, which are crucial to the development of ATCS. This study investigates this relationship through an extensive simulation of scenarios in Hong Kong with a recently developed dynamic traffic control model, DISCO. Based on the Hong Kong scenarios conducted with DISCO, the major findings include: (i) the importance of resolution outweighs that of error; (ii) dynamic timing plans generally outperform time-invariant timing plans; (iii) up to a certain extent, overestimated predictions lead to better results than underestimated predictions.


This paper developed a cell-based dynamic traffic assignment (DTA) formulation that follows the ideal dynamic user optimal (DUO) principle. Through defining an appropriate gap function, we transformed a formulation based on the nonlinear complementarity problem to an equivalent mathematical program. To improve the accuracy of dynamic traffic modelling, this formulation encapsulates a network version of the cell transmission model (CTM). We set up four scenarios to evaluate the properties of this formulation, in the areas of traffic dynamics, traffic interactions across multiple links, and the ideal DUO principle. This formulation produced outputs that are in agreement with what the results ought to be. Namely, the formulation is able to capture dynamic traffic phenomena, such as shock-waves, queue formation, and dissipation. Moreover, it is capable of capturing dynamic traffic interactions across multiple links. Both of these characteristics are inherent from the underlying traffic model adopted in this formulation. The results also demonstrate that this cell-based formulation follows the ideal DUO principle.


This paper developed a cell-based dynamic traffic assignment formulation that follows the ideal dynamic user optimal (DUO) principle through a variational inequality approach. To improve the accuracy of dynamic traffic modeling, this formulation encapsulates a network version of the Cell Transmission Model (CTM). Moreover, this formulation satisfies the first-in-first-out (FIFO) conditions through the CTM. For solutions, we employed an alternating direction method developed for co-coercive variational inequality problems. We set up two scenarios to evaluate the properties of this formulation, in the areas of traffic dynamics and the ideal DUO principle. The results showed that the formulation was capable of capturing dynamic phenomena, such as shockwaves, queue formation and dissipation. Moreover, the results demonstrated that this cell-based formulation produced solutions that precisely followed the ideal DUO principle.

AB This study developed a dynamic traffic control system designated as Dynamic Intersection Signal Control Optimization (DISCO). DISCO considers the entire Fundamental Diagram of traffic flow; which is essential for controlling congested and transient traffic. As a dynamic model, DISCO works with time-varying traffic patterns and derives dynamic adaptive timing plans. In this study, we applied DISCO to a congested network in Hong Kong and compared the performance of various control strategies enabled by DISCO. The results showed that DISCO outperformed the existing plans by more than 50% in terms of overall delay reduction. Moreover, DISCO performed best under the most flexible control scheme of "variable green - no cycle" strategy. DISCO shows promise as a new approach for demand-responsive traffic control.


AB This study developed a dynamic traffic control formulation designated as dynamic intersection signal control optimization (DISCO). Traffic in DISCO is modeled after the cell-transmission model (CTM), which is a convergent numerical approximation to the hydrodynamic model of traffic flow. It considers the entire fundamental diagram and captures traffic phenomena such as shockwaves and queue dynamics. As a dynamic approach, the formulation derives dynamic timing plans for time-variant traffic patterns. We solved DISCO based on a genetic algorithm (GA) approach and applied it to a traffic black spot in Hong Kong that is notorious for severe congestion. For performance comparisons, we also applied TRANSYT to the same scenarios. The results showed that DISCO outperformed TRANSYT for all the scenarios tested especially in congested traffic. For the congested scenarios, DISCO could reduce delay by as much as 33% when compared with TRANSYT. Even for the uncongested scenarios, DISCO's delays could be smaller by as much as 23%.


AB This study developed a dynamic traffic-control formulation that considers the entire Fundamental Diagram. This incorporation of the Fundamental Diagram is especially important for modeling oversaturated traffic. For this purpose, traffic is modeled after the cell-transmission model (CTM), which is a convergent numerical approximation to the hydrodynamic model. We transformed CTM to a set of mixed-integer constraints and subsequently cast the dynamic signal-control problem to a mixed-integer linear program. As a dynamic platform, the formulation is flexible in dealing with dynamic timing plans and traffic patterns. It can derive dynamic as well as fixed timing plans and address preexisting traffic conditions and time-dependent demand patterns. This study produced results to show the benefit of dynamic timing plans and demonstrated that some of the existing practice on signal coordination could be further improved.


AB This paper proposes an alternate formulation of the traffic assignment problem using route flows and the shortest Origin-Destination (OD) travel times as the decision variables. This is accomplished through defining a gap function to convert the nonlinear Complementarity Problem (NCP) formulation to an equivalent Mathematical Program (MP). This formulation has two advantages: (i) it can model assignment problems with general route costs which cannot be accomplished with existing formulations that use link-flow variables, (ii) the objective function is smooth, convex, and bounded, which permits efficient MP algorithms for its solution. Two solution approaches are developed to solve the proposed formulation. The first is based on a set of working routes, which are modeled as "known a priori" based on travelers' preferences or interviews. The second approach uses a column generation procedure to generate a new route in each iteration on a need basis. For each approach, we use a Successive Quadratic Programming (SQP) algorithm to solve for the solutions. To show that the formulation is correct, we solve a small example with a general route cost and compare it to the
classic traffic equilibrium problem which assumes an additive route cost function. Finally, numerical results for a medium-sized network are provided to demonstrate the feasibility of the solution approach.


A novel traffic signal control formulation is developed through a mixed integer programming technique. The formulation considers dynamic traffic, uses dynamic traffic demand as input, and takes advantage of a convergent numerical approximation to the hydrodynamic model of traffic flow. As inherent from the underlying hydrodynamic model, this formulation covers the whole range of the fundamental relationships between speed, flow, and density. Kinematic waves of the stop-and-go traffic associated with traffic signals are also captured. Because of this property, one does not need to tune or switch the model for the different traffic conditions. It "automatically" adjusts to the different traffic conditions. We applied the model to three demand scenarios in a simple network. The results seemed promising. This model produced timing plans that are consistent with models that work for unsaturated conditions. In gridlock conditions, it produced a timing plan that was better than conventional queue management practices.


To model the impact of advanced transportation management and information systems, especially route guidance and other traffic information systems, it is often necessary to develop traffic models that acknowledge the existence of different user classes and that acknowledge that each class may respond to traffic information differently. As a minimum the model should differentiate vehicles that receive real-time traffic information from those that do not. Most existing approaches that incorporate multiple user classes are based on simulation. Although there are advantages of doing so, their main disadvantage is lack of solution quality and property. Recognizing the importance of these, an analytic approach in which the solution properties and quality are well defined is developed. The users are divided into three classes: (a) fixed-route travelers, (b) stochastic dynamic user-optimal, and (c) dynamic user-optimal. The approach defines the property of each class and integrates each into one modeling framework through a variational inequality formulation. Subsequently, a solution algorithm for the formulation is provided and the results of the algorithm are verified through six scenarios.


This paper describes the new traffic assignment modeling provided by the Highway analysis component of the TRIPS package. This tackles some fundamental modeling issues regarding the time-dependent effects of varying flow levels, the effect of assignment modeling on the travel demand origin-destination matrix, and the effect of network interactions between intersections, over time, and as influenced by traffic control strategies. Much of the modeling is an extension of, rather a radical replacement to, previous modeling.


The mathematical models used to describe the dynamical behaviour of a group of closely-spaced road vehicles travelling in a single lane without overtaking are known as car-following models. This paper presents a novel car-following model, which differs from the traditional models by having an equilibrium solution that corresponds to consecutive vehicles having not only zero relative velocity, but also travelling at a certain desired distance apart. This new model is investigated using both numerical and analytical techniques. For many parameter values the equilibrium solution is stable to a periodic perturbation but, for certain parameter values, chaotic motion results. This shows that in congested traffic, even drivers attempting to follow a safe driving strategy, may find themselves driving in an unpredictable fashion.

AB: This paper firstly analyzes the effects of traffic management on dynamic traffic properties. Then focused on signal control and management, the dynamic user optimal (DUO) model considering intersection signal control (ISC) is discussed and proposed in this paper. And aiming at this new model, we also issued the disadvantages of the model such as its unreasonable simplification to intersection signal control mode. So we proposed the improved scheme, which is to transfer the ISC mode into a series of virtual links and to integrate these links into the whole links. This method can solve the question of simulation of ISC well and easily. At last the application foreground of this model such as to discuss the effects of signal control management on the whole traffic network, to analysis traffic capacity and queue length of link at the intersection and assess them with this model is discussed in this paper.


AB: A modeling framework is developed to assess the performance of driver information systems. The two main components of the framework are a route choice module and a traffic simulation module. In the route choice module, three types of driver information systems are studied: the pretrip information service, the in-car route guidance system, and the variable message signs. The traffic simulation module controls the dynamics in a road network as traffic evolves over time in response to driver information. The dynamic properties of the framework are demonstrated in a test network and a simplified Singapore road network. The results suggest that there could be an optimal level of subscription to driver information or market penetration. Subscription to real-time driver information services is recommended, but a high level of subscription may result in extra delay. Variable message signs are not as effective as either pretrip information or in-car route guidance at their respective optimal levels of market penetration.


AB: An extension of a recent framework for analyzing the time-dependent departure pattern arising in an idealized situation of a pool of commuters going from a single origin to a single destination along a unique route is presented. Congestion along this route is represented using elementary traffic flow theoretic relationships; time-varying patterns of basic traffic variables are derived under user equilibrium conditions, along with the corresponding time-dependent departure pattern of system users. After demonstrating the basic model in the single-route context, an additional dimension of choice is introduced by considering the joint departure time and route choice decisions of users.


AB: The evaluation of on-line intelligent transportation system (ITS) measures, such as adaptive route-guidance and traffic management systems, depend heavily on the use of faster than real time traffic simulation models. Fast-running traffic models are needed off-line for use In Iterative approaches that imitate drivers' adaptation to changes to the network topology. This paper describes a simulation-based dynamic-equilibrium traffic assignment model. The determination of time-dependent path flows is modeled as a master problem that
is solved using the method of successive averages (MSA). The determination of path travel times for a given set of path flows is the network-loading sub-problem, which is solved using the space-time queueing approach of Mahut [10]. This loading method has been shown to provide reasonably accurate results with very little computational effort (9)[10]. The model was applied to the Stockholm road network, which consists of 4342 links, 1980 nodes and 250 zones, representing over 11,000 turns. The results show that this model is applicable to medium-size networks with a very reasonable computation time.


An innovative approach that uses static origin-destination (O-D) matrices to model travel demand in dynamic urban traffic models is presented. Dynamic traffic assignment models require the use of time-dependent or dynamic O-D matrices whose acquisition and estimation can be costly and whose consistency can prove difficult to maintain, whereas static O-D matrices of overall trip demand have been estimated for various cities during the last decade. In contrast, the synthetic approach describes the user departure time behavior in a separate model that splits the demand specification into two distinct blocks: the departure time behavior and the time-independent trip demand. Pros and cons of this method are presented with an application to the Paris region with the dynamic simulator METROPOLIS. Guidelines for model designers and planners who are considering the shift to dynamic traffic simulation tools are also presented.


The paper presents a discrete time equilibrium traffic assignment model for urban road networks. The equilibrium state can be chosen either user optimized (in the sense of Wardrop's first principle) or system optimized. The model is capable of taking into account various kinds of network characteristics and constraints like o-d-matrices, link capacities, traffic counts and known intersection splitting rates. Congestion phenomena are modeled by traffic dependent link speed and link inflow restrictions. The task is interpreted as a nonlinear dynamic system control problem and a special recurrent neural network, together with its associated error-propagation network, is used for both identification and control of the system. Flow splitting rates serve as control parameters which have to be adjusted according to the minimization of some objective function (comprising the sum of link travel times). The necessary gradient information can be computed very rapidly by means of a modified version of the recurrent backpropagation algorithm. Because of the use of neural network like structures, the process should be suitable to get implemented on massively parallel hardware.


This paper presents a look at dynamic user optimal traffic assignment as a time delay optimal control problem. The approach proposed here allows us to develop a model for solving the predictive and dynamic user optimal assignment problem which is capable for considering both time-delay effects in the dynamic of link traffic flow and the information providing process to travelers.


The existing models for predicting dynamic travel demand and analyzing travel behaviour are reviewed in this paper. Based on their application domain, the models are classified into six groups as follows, departure time decision, dynamic traffic assignment, dynamics of commuting decision behaviour, dynamic simulation of macroscopic traffic flow, dynamic travel behaviour analysis and time-of-day travel demand forecasting. The advantages and disadvantages of each model are discussed and directions for future research are proposed.

AB A discrete time model is presented for dynamic traffic assignment with a single destination. Congestion is treated explicitly in the flow equations. The model is a nonlinear and nonconvex mathematical programming problem. A piecewise linear version of the model, with additional assumptions on the objective function, can be solved for a global optimum using a one-pass simplex algorithm. EM DASH branch-and-bound is not required. The piecewise linear program has a staircase structure and can be solved by decomposition techniques or compactification methods for sparse matrices.


Abstract: A dynamic traffic assignment model formulated as a nonlinear and nonconvex mathematical program is described. Necessary optimality conditions require equalization of certain marginal costs for all the paths that are being used, and these optimality conditions are shown to be a generalization of the optimality conditions of a conventional static traffic assignment problem. The behavior of the dynamic model under static demand conditions is also examined and it is shown that in this case the model presented is a generalized version of a standard static model.


AB The success of Advanced Traffic Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS) depends on the availability and dissemination of timely and accurate estimates of prevailing and emerging traffic conditions, as well as the provision of faithful and coherent pretrip and en-route travel information and advisory to travelers. Real-time Dynamic Traffic Assignment (DTA) systems, envisioned as an ATMS support system that resides in transportation management centers, are being developed to supply these estimates and information. To ensure the deployment potential of such DTA systems in the field, extensive laboratory evaluations are required throughout the development process. This article discusses a software environment that economically supports the development and evaluation of DTA systems. A major simulation component developed under this environment is called a DTA evaluation system (DES). The DES is a virtual representation of a transportation system in which ATMS and ATIS technologies are deployed. It simulates the trip-making and vehicle-driving behaviors of travelers in response to real-time information and advisories from ATIS and ATMS. This article presents (1) major DES modeling capabilities required for developing and evaluating DTA systems, (2) a modular and extensible modeling framework for the DES, and (3) a top-level, object-oriented, and distributed DES design.


AB Travel demand analyses are useful for transportation planning and policy development in a study area. However, travel demand modeling faces two obstacles. First, standard practice solves the four travel components (trip generation, trip distribution, modal split and network assignment) in a sequential manner. This can result in inconsistencies and non-convergence. Second, the data required are often complex and difficult to manage. Recent advances in formal methods for network equilibrium-based travel demand modeling and computational platforms for spatial data handling can overcome these obstacles. In this paper we report on the development of a prototype geographic information system (GIS) design to support network equilibrium-based travel demand models. The GIS design has several key features, including: (i) realistic representation of the multimodal transportation network, (ii) increased likelihood of database integrity after updates, (iii) effective user interfaces, and (iv) efficient implementation of network equilibrium solution algorithms.

AB Travel times in congested transportation networks are time-varying quantities that can at best be known a priori probabilistically. In such networks, the arc weights (travel times) are represented by random variables whose probability distribution functions vary with time. These networks are referred to herein as stochastic, time-varying, or STV, networks. The determination of "least time" routes in STV networks is more difficult than in deterministic networks, in part because, for a given departure time, more than one path may exist between an origin and destination, each with a positive probability of having the least travel time. In this paper, measures for comparing time-varying, random path travel times over a time period are given for both a priori optimization and time-adaptive choices (where a driver may react to revealed arrival times at intermediate nodes). The resulting measures are central to the development of methodologies for determining "optimal" paths in STV networks.


AB Traffic management methods often employ network flow models that use data collected by a surveillance system to estimate the current state of the network and predict its evolution over time. Origin-Destination (OD) flows comprise one of the main elements of the network state. This paper focuses on the role of various types of surveillance data in the real-time estimation of dynamic OD flows. Traditionally, traffic surveillance is carried out using inductive loop detectors. While providing an inexpensive means of monitoring traffic, such detectors do not provide any data on traffic conditions beyond the detection point. Recent advances in communication, computing, and electronics are enabling the development of remote sensing-based surveillance systems which involve the observation of the roadway network from a fairly high vintage point. Such sensors can provide extended spatial coverage of the network, thus, capturing vehicle trajectories, queue lengths, and link travel times. Such data have the potential to improve the accuracy of the network state estimates along with traffic predictions and, consequently, result in more effective traffic management. This study quantifies the value of using intersection turning fraction and link travel time measurements, which are available from remote sensing-based surveillance systems, in estimating OD flows in real-time. A network consisting of three adjacent intersections is used to conduct an empirical analysis.


AB In a static travel demand forecasting model, all trips between any origin and destination are assumed to be completed within the specific time period being modeled. Further, static models do not account for the temporal variations in travel demand. A dynamic model overcomes the above limitations. The temporal variation in travel demand is accounted within a dynamic model by disaggregating the time period being modeled into finite time slices. During assignment, each origin-destination pair is progressed along the network to the extent possible with each time slice. Consequently, a trip may take several time slices to reach its destination, or may not reach its destination within the time period being modeled. This paper compares the results from a static model with those from a dynamic model for a study network in the Boston metropolitan area. Comparison of the results are presented in terms of traffic assignments on individual links, as well as on a system-wide basis. Effects from the difference in results between static and dynamic models on traffic operational analysis (level of service analysis) and air quality analysis are discussed.


AB In this paper we consider the solution of a dynamic traffic network model with elastic demands modeled as a projected dynamical system in which the demand functions are assumed to be given. The proposed discrete
time algorithm, the Euler method, resolves the problem at each step into subproblems in path flow and travel disutility variables, all of which can be solved simultaneously and in closed form. Convergence results that depend crucially on stability analysis are also presented. We then discuss the implementation of the algorithm on the massively parallel architecture, the Thinking Machine's CM-5. We conclude with the presentation of numerical results for the parallel implementation of the Euler method in CM Fortran on the CM-5 and for a serial implementation in Fortran on the IBM SP2 for several traffic network examples.


AB The need to simulate a number of advanced ITS concepts prior to deployment necessitated development of high performance microscopic simulators for heuristic dynamic traffic assignment, freeway corridor diversion, driver information systems including variable message signs and vehicle guidance systems, real-time adaptive traffic control and other traffic management concepts. In spite of recent progress in developing sophisticated simulators for ITS applications their employment in real life projects requires substantial data collection, testing, validation and calibration. The latter is often ignored in practice where for convenience simulators are often used without sufficient validation and calibration, resulting in unreliable and/or inaccurate results. The objective of this paper is to demonstrate the issues and lessons learned in the employment of a sophisticated simulator for evaluating the effectiveness of adaptive ramp control in the Twin cities of Minneapolis and St. Paul, which is one of the earliest and most extensive worldwide (210 miles of freeway, 430 ramp meters).


AB This paper proposes, for a fixed demand traffic network problem, a route travel choice adjustment process formulated as a projected dynamical system, whose stationary points correspond to the traffic equilibria. Stability analysis is then conducted in order to investigate conditions under which the route travel choice adjustment process approaches equilibria. We also propose a discrete time algorithm, the Euler method, for the computation of the traffic equilibrium and provide convergence results. The notable feature of the algorithm is that it decomposes the traffic problem into network subproblems of special structure, each of which can then be solved simultaneously and in closed form using exact equilibration. Finally, we illustrate the computational performance of the Euler method through various numerical examples.


AB Most analyses of driver-network transportation systems rest on the presence of network equilibrium. Equilibrium analyses presuppose that the driver is rational and homogeneous and has perfect information. A more realistic view, however, is that individuals' rationality is bounded because of their cognitive limitations. A driver is assumed to adopt simple rules when he chooses a route. A model system in which the driver's learning is simulated with multiple rules is applied to investigate the validity of the hypotheses underlying network equilibrium. The results of simulation analyses can be summarized as follows. Drivers do not become homogeneous and rational, as equilibrium analyses presuppose; rather, there are fewer rational drivers even after a long process of learning, and heterogeneous drivers make up the system. Drivers' attitudes toward and perceptions of each route do not become homogeneous either but become bipolar. The results point to the need for a critical appraisal of the foundation of the equilibrium analysis of network flow.

In this study drivers are assumed to reason and learn inductively based on the theory of cognitive psychology. The model system is basically a production system, a compilation of if-then rules in which the rules are revised by applying genetic algorithms. The behavior of drivers and network flow through Monte Carlo simulation using the model system is examined. The intention of this research is to shed light on the behavior of a driver-network system from a new standpoint, one different from that of equilibrium analysis. This research views drivers' behaviors as psychological and heterogeneous rather than economical and homogeneous. The results of the numerical experiments can be summarized as follows: (1) network flow does not necessarily converge to the user equilibrium; (2) drivers form a delusion, an extremely biased perception of travel time as a result of experiencing excessive travel times on early parts of the simulation in which little experience had been gained; (3) the delusion is dissolved by switching routes capriciously; and (4) without caprice drivers continue to travel on the same route because of their delusions and develop the habit of choosing the same route, thus freezing their behaviors. These results indicate that system behavior is much more complex and dynamic than implied by equilibrium analysis.


A model system of drivers' cognition, learning, and route choice is formulated, taking into account the limitations in drivers' cognitive capabilities, and is applied to examine the dynamic nature of a driver-network system through microsimulation. Network equilibrium is not assumed a priori; rather, finding how an equilibrium is reached, or not reached, is the objective. Although equilibrium analysis, in general, focuses on unique and static equilibrium by treating drivers' behavior as simply as possible, drivers' behavior is treated more realistically to enhance understanding of the day-to-day dynamics of the driver-network system. Results of microsimulation analyses indicate that the network flow does not necessarily converge to user equilibrium; instead, it may reach 'deluded equilibrium,' which is caused by drivers' false perceptions of travel times, and have 'path dependence.' Results, especially the complex behavior such as path dependence shown in the simulation, indicate that the driver-network system is a complex system.

Nambisan, SS, Pulugurtha, SS (2001) Estimating time-dependent origin-destination trip tables with trips originating in multiple time slices. Transportation Research Record 1752: Travel Patterns And Behavior; Effects Of Communications Technology, 133-139.

Intelligent transportation system initiatives, such as travel information systems and travel demand management systems, have been used to ameliorate problems with congestion due to increasing travel demand. The success of these initiatives depends on the ability to accurately estimate the temporal variations in travel demand. A modeling framework based on arrival patterns of trips at workplaces and travel times in urban areas is presented. The peak period is divided into short, discrete intervals of time called time slices. Origin-destination trip tables for each time slice are estimated on the basis of when a trip with a certain travel time must have started to arrive at the destination in a specified time slice. There are two possibilities for the time slice in which a trip might have originated: (a) starting in time slice k - 1 and ending in time slice m and (b) starting in time slice k and ending in time slice m (m greater than or equal to k). A model is presented to estimate the probability that the trip might have originated in time slice k - 1 and time slice k On the basis of these probabilities, the performance of the model is tested using data for the Las Vegas metropolitan area.


This paper describes additional ways in which TRIPS models time-varying, or 'dynamic' effects. These include area-wide effects as vehicles move through the network, interactions between intersections, and the effects of extended modelling periods. Although the modelling changes are directed at the behavior of traffic on a network, a significant result is the information given about the consequences for the demand for travel. This information is in the form of a pair of Origin-Destination (O-D) matrices. The paper considers the issues
addressed by dynamic modelling and the key elements of the TRIPS implementation. The methods used are briefly described, and the paper concludes by considering how dynamic modelling may best be applied.


AB This paper presents a new graph theoretic framework for the passenger assignment problem that encompasses simultaneously the departure time and the route choice. The implicit FIFO access to transit lines is taken into account by the concept of available capacity. This notion of flow priority has not been considered explicitly in previous models. A traffic equilibrium model is described and a computational procedure based on asymmetric boarding penalty functions is suggested.


AB In this paper, we propose and analyze some implicit projected dynamical systems associated with quasi variational inequalities by using the techniques of the projection and the Wiener-Hopf equations. We prove that the globally asymptotic stability of these dynamical systems requires only the pseudomonotonicity of the operator, which is a weaker condition than monotonicity. We also discuss some special cases, which can be obtained from our main results. The results obtained in this paper represent a significant improvement of the previously known results.


AB In this paper, we suggest and analyze a class of implicit resolvent dynamical systems for quasi variational inclusions by using the resolvent operator technique. We show that the trajectory of the solution of the implicit dynamical system converges globally exponentially to the unique solution of the quasi variational inclusions. Our results can be considered as a significant extension of the previously known results.


AB In this paper, we propose and analyse a modified projection-type dynamical system associated with variational inequalities by using the technique of updating the solution. We prove that the globally asymptotic stability of this dynamical system requires only the pseudomonotonicity of the underlying operator, which is a weaker condition than monotonicity. The results obtained in this paper represent a significant improvement of the previously known results.


AB In order to improve the performances of transit modeling and in particular to assess the effects of the introduction of ITS technologies, which imply substantial changes in user behavior, in the last 10 years transit path choice and assignment models that use a schedulebased approach, instead of the traditional frequency-based one, have been developed. This paper presents a schedule-based path choice model for high-frequency transit networks, which allows us to consider the evolution in time of transit services, both within-day and day-to-day, as well as the day-to-day learning process of attributes by which users choose. On the basis of this path choice model a dynamic process assignment model, both within-day and day-to-day (from which the term "doubly dynamic" derives), was developed and tested on a realistically sized network to verify its applicability for operations planning.

**AB** This paper, with reference to high frequency transit systems with waiting time user information and with regular arrival of services at stops, proposes a dynamic stochastic path choice model that explicitly considers within-day variation and day-to-day evolution of the system. The path choice model is used together with a diachronic network model in a transit doubly dynamic assignment model, which is analysed with a deterministic approach, as a non linear dynamic system.


**AB** In a general multimodal system, interface and interaction coordination involves the deliberate assembly of modal movement units MMU's (i.e., vessel, vehicle, or rail car) activities into schedules such that interfaces are facilitated, and the joint variable cost of coordination of intermodal interaction is minimized. In this paper, two methods of nonstochastic scheduling coordination are described, and their application in a globally integrated transport system network model is shown [1]. The first method expresses the scheduling problem in the form of the Hitchcock transportation problem in accordance with a method derived by Dantzig and Fulkerson [2]. The second method is derived from network flow theory and is based on the 'out-of-kilter' method devised by Fulkerson [3]. This paper seeks to provide a basis for implementing dedicated logistics submodels such as MMU and staff scheduling submodels, and to examine MMU staffing requirements on a selected real system. These minimize the ratio of labor for scheduling modal interactions, and modal coordination to the frequency of arrivals/departures at a consolidation node, thereby maximizing MMU availability, and minimizing MMU system maintenance costs.


**AB** A framework is developed to parametrically evaluate networks under user equilibrium route guidance (UERG) and system optimal route guidance (SORG), assuming that the unguided traffic is in stochastic user equilibrium. The framework can determine in what condition an advanced traveler information system performs well and which route guidance state performs better as the market penetration of guidance systems increases. Unlike other studies that assumed a fixed number of compliant drivers, this study explicitly considers compliance rate as an endogenous variable in a general parametric nonlinear programming framework. Under endogenously determined compliance rate, SORG may result in a higher total system cost than UERG because of a lower compliance rate, even though SORG aims to minimize total system cost. In contrast, even though UERG is generally preferable because of higher acceptance, it may result in increased total system cost under certain conditions. A simple network is used to illustrate the application of the framework and show that the performance of route guidance is highly dependent on the level of unguided drivers' familiarity with the network. A significant part of the framework is the scheme to find "sustainable" compliance rates under assumed compliance function.


**AB** The annual number of flights in Western Europe has increased from about 2.6 million in 1982 to about 4.5 million in 1992, an increase of 73%. Acute congestion of the Air Traffic Control system has been the result. One way to reduce this congestion is to modify the flight plans (slot of departure and route) in order to adapt the demand to the available capacity. This paper addresses the general time-route assignment problem. A state of the art of the existing methods shows that this problem is usually partially treated and the whole problem remains unsolved due to the complexity induced. We perform our research on the application, of stochastic methods on real traffic data, and without using the flow network concept, but by simulating the flight of each
aircraft. The first results shows that our Genetic Algorithms based method is able to reduce congestion of the French airspace by a factor 2. Special coding techniques and operators are used to improve the quality of the genetic search.


AB Stochastic learning automata (SLA) theory is used to model the learning behavior of commuters within the context of the combined departure time route choice (CDTRC) problem. The SLA model uses a reinforcement scheme to model the learning behavior of drivers. A multi-action linear reward-c-penalty reinforcement scheme was introduced to model the learning behavior of travelers based on past departure time choice and route choice. A traffic simulation was developed to test the model. The results of the simulation are intended to show that drivers learn the best CDTRC option, and the network achieves user equilibrium in the long run. Results indicate that the developed SLA model accurately portrays the learning behavior of drivers, while the network satisfies user equilibrium conditions.


AB Day-to-day route choice behavior of drivers is analyzed by the introduction of a new route choice model developed using stochastic learning automata (SLA) theory. This day-to-day route choice model addresses the learning behavior of travelers on the basis of experienced travel time and day-to-day learning. To calibrate the penalties of the model, an Internet-based route choice simulator (IRCS) was developed. The IRCS is a traffic simulation model that represents within-day and day-to-day fluctuations in traffic and was developed using Java programming. The calibrated SLA model is then applied to a simple transportation network to test if global user equilibrium, instantaneous equilibrium, and driver learning have occurred over a period of time. It is observed that the developed stochastic learning model accurately depicts the day-to-day learning behavior of travelers. Finally, the sample network converges to equilibrium in terms of both global user and instantaneous equilibrium.


AB Algorithms for solving finite-dimensional inequalities are studied. The emphasis is on numerical methods based on the optimization approach. Examples of economic equilibrium models that assist in solving variational inequalities are presented.


AB A macroscopic modeling framework for dynamic traffic phenomena on multideestination freeway and/or road networks with time varying demands is developed. A key variable of the model at each network node are the splitting rates of each traffic subflow with a specific destination. Two approaches are investigated for resolving the dynamic assignment and the route guidance problem: first, an optimal control approach for achieving a dynamic system or user optimum; second, a feedback concept for establishing dynamic user optimal conditions. The overall approach allows for integrated design of individual and/or collective route guidance, ramp metering, and signal setting in freeway and/or road networks. Some examples are provided.

We study the connections between solutions of variational inequalities and equilibrium points of a
generalized dynamical system. Furthermore, we analyze some stability questions arising in this field.

dynamic traffic conditions. Proceedings Of The Eastern Asia Society For Transportation Studies (4th
Conference of the Eastern-Asia-Society-for-Transportation-Studies), VOL 3, NO 2, Miyamoto K (ed), 57-68.

Dynamic traffic assignment (DTA) has been a topic of substantial research in the last two decades and it
has recently received growing attention, with the news that it will utilize Advanced Traffic Information
Systems (ATIS) applications. However, DTA has many mathematical difficulties in searching its solution due to
the complexity of spatial and temporal variables. Although many solution algorithms have been developed,
conventional methods cannot find a solution when an objective function or constraints is not convex. In this
paper, we provide a new method using a genetic algorithm (GA) to solve the DTA model. To apply this new
method, we formulated the DTA model based on Merchant-Nemhauser's model (1978), which has a nonconvex
constraint set. To handle the nonconvex constraint set, the GENOCOP III system, which is one of the GAs, is
used in this study. Results for the sample network have been compared with the results of conventional method.

Systems with Applications 21, 217-227.

This paper presents a new approach to solve dynamic traffic assignment problems. The approach
employs a mixed method of real-time simulation and off-line optimization. The fundamental approach to the
simulation is systolic parallel processing based on autonomous agent modeling. Agents continuously act on
their own initiatives and access to database to get the status of the simulation world. In particular, existing
models and algorithms were incorporated in designing the behavior of relevant agents such as car-following
and headway distribution. Simulation is based on predetermined routes between centroids that are computed
off-line by a conventional optimal path-finding algorithm such as the Frank-Wolf algorithm. Iterating the
cycles of optimization and simulation, the proposed system will provide a practical and valuable traffic
assignment. Gangnam-Gu district in Seoul, Korea is selected as the target area for the modeling. It is expected
that real-time traffic assignment services can be provided on the Internet soon.


The existing dynamic and stochastic shortest path problem (DSSPP) algorithms assume that the mean
and variance of link travel time (or other specific random variable such as cost) are available. When they are
used with observed data from previous time periods, this assumption is reasonable. However, when they are
applied using forecast data for future time periods, which happens in the context of ATIS, the travel time
uncertainty needs to be taken into account. There are two components of travel time uncertainty and these are
the individual travel time variance and the mean travel time forecasting error.

The objectives of this study are to examine the characteristics of two components of travel time uncertainty,
to develop mathematical models for determining the mean and variance of the forecast individual travel time in
future time periods in the context of ATIS, and to validate the proposed models. First, this study examines the
characteristics of the two components of uncertainty of the individual travel time forecasts for future time
periods and then develops mathematical models for estimating the mean and variance of individual route travel
time forecasts for future time periods. The proposed models are then implemented and the results are evaluated
using the travel time data from a test bed located in Houston, Texas. The results show that the proposed DSSPP
algorithms can be applied for both travel time estimation and travel time forecasting.


This paper explores stability issues for operational route guidance control strategies for vehicular traffic
networks equipped with advanced information systems, and develops a general procedure for the stability
analysis of the associated dynamic traffic assignment (DTA) problems. The route guidance control strategies
are modeled as dynamical systems, and the associated solution procedure enables computational tractability for
real-time deployment. An important study insight is that the Lyapunov functions for the route guidance control models are their corresponding objective functions under DTA. This overcomes the key difficulty of constructing meaningful Lyapunov functions for DTA problems.


AB The variable message sign (VMS) represents a cost-effective mechanism for disseminating information to drivers unequipped to receive personalized information. The VMS can be used during incidents to divert traffic to less congested areas of the network and circumvent lengthy queues, better utilize network capacity, and improve system performance. A VMS control heuristic framework is proposed and evaluated that seeks diversion during incidents to enable a traffic system controller to favorably manage traffic conditions in real time. The framework ensures consistency with driver diversion response behavior, is responsive to changing traffic conditions, enables computational tractability through stage-based online implementation, and ensures the spatial and temporal consistency of the displayed messages. A hybrid framework is used that consists of offline and online components to determine the information for the VMS. The ability to display messages consistent with driver diversion behavior represents a valuable tool for the controller to enhance system effectiveness by simultaneously satisfying systemwide and individual user objectives. Data on driver VMS response attitudes from the Borman Expressway corridor in northwestern Indiana and simulated experiments are used to derive insights into the practical effectiveness of the proposed VMS control heuristic.


AB This paper explores stability issues for a dynamical systems based traffic assignment model for vehicular traffic networks equipped with advanced information systems and develops a real-time deployable solution algorithm. Experimental analysis suggests that the algorithm can efficiently provide real-time stable solutions while accounting for time-dependent variations in the system. The results are compared to those of the benchmark deterministic dynamic traffic assignment and the rolling horizon implementation based models.


AB Advanced technologies under the aegis of advanced traveler information systems and advanced traffic management systems are being employed to address the debilitating traffic congestion problem. Broadly identified under the label intelligent transportation systems (ITS), they focus on enhancing the efficiency of the existing roadway utilization. Though ITS has transitioned from the conceptual framework stage to the operational test phase that analyzes real-world feasibility, studies that systematically quantify the multidimensional real-world impacts of these technologies in terms of mobility, safety, and air quality, are lacking. This paper proposes a simulation-based framework to address the mobility impacts of these technologies through the provision of information to travelers. The information provision technologies are labeled as advanced information systems (AIS), and include pretrip information, en route information, variable message signs, and combinations thereof. The primary focus of the paper is to evaluate alternative AIS technologies using the heavily traveled Borman Expressway corridor in northwestern Indiana as a case study. Simulation results provide insights into the mobility impacts of AIS technologies, and contrast the effectiveness of alternative information provision sources and strategies.


AB A framework for ensuring operational consistency of on-line dynamic traffic assignment in networks with advanced traffic management and information systems is proposed and investigated. Formulated within a stage-based rolling horizon framework, the model first solves a deterministic dynamic traffic assignment
problem to predict the traffic network state for the near future while optimizing certain controller and user objectives and later seeks consistency between the predicted system state and the actual conditions unfolding on line. This approach ensures that future state predictions and path assignments are consistent with the current actual system state rather than the previously predicted (presumed) system state. The consistency problem is formulated as a constrained least-squares model. It is underdetermined, rank deficient, and potentially ill conditioned for general networks. In addition, it lacks well-behaved properties and has a fixed-point element, characteristics inherited from the dynamic traffic assignment problem. It is solved using orthogonal transformations based on generalized singular value decomposition (GSVD). Simulation experiments are conducted to analyze the effectiveness of the GSVD-based solution algorithm vis-a-vis ensuring consistency. The experiments emphasize the reliability and stability of GSVD in addressing the on-line consistency problem.

Peeta, S, Zhou, C (1999) Robustness of the off-line a priori stochastic dynamic traffic assignment solution for on-line operations. Transportation Research 7C, 281-303. AB This paper focuses on the off-line stochastic dynamic traffic assignment (DTA) problem as part of a hybrid framework that combines off-line and on-line strategies to solve the on-line DTA problem. The primary concept involves the explicit recognition of stochasticity in O-D demand and/or network supply conditions to determine a robust off-line a priori solution that serves as the initial solution on-line. This strategy ensures that the computationally intensive components, which exploit historical data, are executed off-line while circumventing the need for very accurate on-line O-D demand forecast models. Thereby, efficient on-line reactive strategies could be used to address unfolding traffic conditions. The paper investigates the robustness of the off-line a priori DTA solution under plausible on-line situations. The results illustrate the superiority of the a priori solution over the currently used mean O-D demand-based solution for on-line route guidance applications.

Peeta, S, Mahmassani, HS (1995) System optimal and user equilibrium time-dependent traffic assignment in congested networks. Annals of Operations Research 60, 81-113. AB This paper formulates two dynamic network traffic assignment models in which O-D desires for the planning horizon are assumed known a priori: the system optimal (SO) and the user equilibrium (UE) time-dependent traffic assignment formulations. Solution algorithms developed and implemented for these models incorporate a traffic simulation model within an overall iterative search framework. Experiments conducted on a test network provide the basis for a comparative analysis of system performance under the SO and UE models.

Peeta, S, Mahmassani, HS (1995) Multiple user classes real-time traffic assignment for online operations - a rolling horizon solution framework. Transportation Research 3C, 83-98. AB Existing dynamic traffic assignment formulations predominantly assume the time-dependent O-D trip matrix and the time-dependent network configuration to be known a priori for the entire planning horizon. However, there is also a need to provide real-time path information to network users under ATIS/ATMS when unpredicted variations in O-D desires and/or network characteristics (e.g. capacity reduction on certain links due to incidents) occur. This paper presents a rolling horizon framework for addressing the real-time traffic assignment problem, where an ATIS/ATMS controller is assumed to have O-D desires up to the current time interval, and short-term and medium-term forecasts of future O-D desires. The assignment problem is solved in quasi-real time for a near-term future duration (or stage) to determine an optimal path assignment scheme for users entering the network in real-time for the short-term roll period. The resulting model is intricate due to the intertemporal dependencies characterizing this problem. Two formulations are discussed based on whether a capability to reroute vehicles on route exists. A rolling horizon solution procedure amenable to a quasi-real time implementation of a multiple user classes (MUC) time-dependent traffic assignment solution algorithm developed previously by the authors is described. Implementation issues are discussed from the perspective of ATIS/ATMS applications.

In traditional, constrained spatial interaction models, the number of predicted movers leaving origins and entering destinations is constrained to match exactly the observed number. In relaxed models, these constraints are allowed to vary over a range of values in order to provide greater flexibility in calibration. This paper identifies a new, seven-member family of relaxed spatial interaction models, based upon the generalization of the constraint sets used in model derivation. Three categories are suggested, including single and doubly relaxed models, cost-relaxed models, and totally relaxed models. This paper introduces these relaxed models as entropy-maximizing ones, proposes a terminology for them, and describes empirical situations in which they are useful.


We consider the problem of dynamically routing a driver to cover a sequence of tasks (with no consolidation), using a complex set of driver attributes and operational rules. Our motivating application is dynamic routing and scheduling problems, which require fast response times, the ability to handle a wide range of operational concerns, and the ability to output multiple recommendations for a particular driver. A mathematical formulation is introduced that easily handles real-world operational complexities. Two new optimization-based heuristics are described, one giving faster performance and the second providing somewhat higher solution quality. Comparisons to optimal solutions are provided, which measure the quality of the solutions that our algorithms provide. Experimental tests show that our algorithms provide high quality solutions, and are fast enough to be run in real-time applications.


The dynamic assignment problem arises in a number of application areas in transportation and logistics. Taxi drivers have to be assigned to pick up passengers, police have to be assigned to emergencies, and truck drivers have to pick up and carry loads of freight. All of these problems are characterized by demands that arrive continuously and randomly throughout the day, and require a dispatcher to assign a driver to handle a specific demand. We use as our motivating application the load matching problem that arises in long-haul truckload trucking, where we have to assign drivers to loads on a real-time basis. A hybrid model is presented that handles the detailed assignment of drivers to loads, as well as handling forecasts of future loads. Numerical experiments demonstrate that our stochastic, dynamic model outperforms standard myopic models that are widely used in practice.

Pribe, CA, Rogers, SO (1999) Learning to associate observed driver behavior with traffic controls. Transportation Research Record 1679, 95-100.

Adaptive techniques support the development of new tools to help traffic engineers classify and evaluate traffic flow at intersections. A tool that learns to associate driver behavior with a subset of traffic controls (e.g., stoplights and stop signs) is described. In the case in which the traffic controls for an intersection are not readily available or are unknown, the tool automatically identifies the traffic controls present at an intersection from observed driver behavior. This capability may be used to augment digital maps with traffic control locations. In the case in which traffic controls are known or have previously been classified, the tool flags instances in which driver behavior is inconsistent with the traffic controls actually present. This capability might be used by various services for drivers such as dynamic routing and new safety systems. It might also be used by traffic engineers to evaluate control placement in real or simulated road networks by finding situations that elicit unusual driver behavior. The tool is calibrated with driving data for a set of segments with known controls. The tool first learns to identify the controls present on individual road segments and then uses handcrafted rules to verify control consistency across segments at intersections. The data set comprised real-
world position data collected during normal daily driving. The tool accurately identified 100 percent of the data that passed verification. These results encourage belief that the system can provide traffic engineers with a reliable mapping between driver behavior and traffic controls.


Although most real-world vehicle routing problems are dynamic, the traditional methodological arsenal for this class of problems has been based on adaptations of static algorithms. Still, some important new methodological approaches have recently emerged. In addition, computer-based technologies such as electronic data interchange (EDI), geographic information systems (GIS), global positioning systems (GPS), and intelligent vehicle-highway systems (IVHS) have significantly enhanced the possibilities for efficient dynamic routing and have opened interesting directions for new research. This paper examines the main issues in this rapidly growing area, and surveys recent results and other advances. The assessment of possible impact of new technologies and the distinction of dynamic problems vis-a-vis their static counterparts are given emphasis.


Intelligent transportation systems (ITS) have been used to alleviate congestion problems arising due to demand during peak periods. The success of ITS strategies relies heavily on two factors: 1) the ability to accurately estimate the temporal and spatial distribution of travel demand on the transportation network during peak periods, and, 2) providing real-time route guidance to users. This paper addresses the first factor. A model to estimate time dependent origin-destination (O-D) trip tables in urban areas during peak periods is proposed. The daily peak travel period is divided into several time slices to facilitate simulation and modeling. In urban areas, a majority of the trips during peak periods are work trips. For illustration purposes, only peak period work trips are considered in this paper. The proposed methodology is based on the arrival pattern of trips at a traffic analysis zone (TAZ) and the distribution of their travel times. The travel time matrix for the peak period, the O-D trip table for the peak period, and the number of trips expected to arrive at each TAZ at different work start times are inputs to the model. The model outputs are O-D trip tables for each time slice in the peak period. 1995 data for the Las Vegas metropolitan area are considered for testing and validating the model, and its application. The model is reasonably robust, but some lack of precision was observed. This is due to two possible reasons: 1) rounding-off, and, 2) low ratio of total number of trips to total number of O-D pair combinations. Hence, an attempt is made to study the effect of increasing this ratio on error estimates. The ratio is increased by multiplying each O-D pair trip element with a scaling factor. Better estimates were obtained. Computational issues involved with the simulation and modeling process are discussed.


This paper discusses an analytical dynamic traffic assignment (DTA) model with the extended capability of performing rolling horizon implementation. This model is formulated as a link-based variational inequality and can be solved efficiently to convergence by a relaxation (diagonalization) algorithm. The rolling horizon mechanism makes this proposed approach a flexible tool in evaluating simulation-based DTA models. According to different assumptions of travelers' route choice behavior, three different classes of travelers are categorized: fixed (predetermined) route class, stochastic dynamic user-optimal class, and dynamic user-optimal class. Model formulation, steps of the algorithm, and rolling horizon implementation are discussed in detail. Computational examples and results are presented and analyzed.

AB In this paper, three traveler classes are classified according to different assumptions of travelers' route choice behavior, including fixed route, stochastic dynamic user optimum, and dynamic user optimum. Note that "multiclass" in this paper refers to travelers' different realization of traffic conditions, instead of representing vehicle types. The three classes of users are integrated into one dynamic traffic assignment (DTA) model and solved using a newly proposed algorithm. In this paper, variables of link flow and exit flow are represented solely by in-flow. The resulting linear program subproblem in the inner iteration is proved and solved as a typical time-dependent shortest route problem over a physical network. Accordingly, the usually required time-space network expansion in solving DTA models is no longer needed. Computational results from a hypothetical network and the Sioux Falls network are reported and analyzed.


AB As a subsystem of an intelligent Transportation System (ITS), an Advanced Traveller Information System (ATIS) disseminates real-time traffic information to travellers. To help travellers better make their route choice decisions, there is a strong need to predict traffic congestion and disseminate the predicted congestion information to travellers. This paper offers some insights and predictions on how ATIS information provision is becoming more pervasive due to recent advances in telecommunication systems. The paper also discusses how ATIS systems will likely evolve based on the experiences of Information Service Providers (ISP) and ATIS modelling specialists. Then, it reviews four types of prediction models: 1) simulation models; 2) dynamic traffic assignment (DTA) models; 3) statistical models; and 4) heuristic models. The functional requirements and capabilities of the four types of prediction models are discussed and summarized. Furthermore, a comprehensive prediction procedure is presented, which combines the four types of prediction models.


AB This paper investigates time-dependent travel time functions for dynamic assignment on signalized arterial network links. Dynamic link travel times are first classified according to various applications. Subsequently, stochastic and deterministic travel time functions for longer and shorter time horizons are discussed separately, and two sets of functions are recommended for dynamic transportation network problems. The implications of those functional forms are analyzed and some modifications for dynamic network models are suggested. In addition, based on dynamic link travel time functions, we discuss how many independent variables are necessary to describe the temporal traffic flow and properly estimate the time-dependent travel time and how propagation over an arterial link. As a result, six link flow variables and corresponding link state and flow propagation equations are proposed as the basis to formulate dynamic transportation network models.


AB The ideal dynamic user-optimal (DUO) route choice problem is to determine vehicle flows on each link at each instant of time resulting from drivers using actual minimal-time routes. Actual route time is the travel time incurred while driving along the route. In a previous paper, we presented a route-based optimal control model for the ideal DUO route choice problem. However, this model is not appropriate for large-scale transportation networks because some degree of route enumeration is necessary to solve the model. In this paper; we first present the traffic network constraints and link-based DUO route choice conditions. Then, we introduce a link-based variational inequality (VI) formulation for the ideal DUO route choice problem so that route enumeration can be avoided in both the formulation and the solution procedure. By proving the necessity
and sufficiency of this VI, we demonstrate that the VI formulation is equivalent to the link-based DUO route choice conditions.


AB The dynamic user-optimal (DUG) departure time and route choice problem is to determine travelers' best departure times and route choices at each instant of time. In a previous paper, we presented a route-based two-level optimal control model for the DUO departure time/route choice problem. However, this model is not appropriate for large scale transportation networks because some degree of route enumeration is necessary to solve the model. In this paper, we present a link-based variational inequality (VI) formulation for the DUO departure time/route choice problem so that route enumeration can be avoided in both the formulation and the solution procedure. The model extends our previous VI model for the DUO route choice problem to the case where both departure time and route over a general road network must be chosen simultaneously. By proving the necessity and sufficiency of this VI, we establish the equivalence of the VI formulation and the link-based DUO departure time/route choice conditions.


AB The instantaneous dynamic user-optimal (DUO) traffic assignment problem is to determine vehicle flows on each link at each instant of time resulting from drivers using instantaneous minimal-time routes. Instantaneous route time is the travel time incurred if traffic conditions remain unchanged while driving along the route. In this paper, we introduce a different definition of an instantaneous DUO state. Using the optimal control theory approach, we formulate two new DUO traffic assignment models for a congested transportation network. These models include new formulations of the objective function and flow propagation constraints, and are dynamic generalizations of the static user-optimal model. The equivalence of the solutions of the two optimal control programs with DUO traffic flows is demonstrated by proving the equivalence of the first-order necessary conditions of the two programs with the instantaneous DUO conditions. Since these optimal control problems are convex programs with linear constraints, they have unique solutions. A numerical example is presented indicating that this class of models yields realistic results.


AB It is important to develop a dynamic route choice model in order to predict instantaneous time-dependent variations of traffic in a road network and realistic travel time of vehicle. Se Hyeon Oh (1995) developed the Instantaneous Dynamic User Optimal (IDUO) Route Choice Model using the model developed by Ran, Boyce and LeBlanc (1993) by adding the overflow delay function. He showed the possibility of predicting the dynamic link travel time by applying this model to the real road network of Seocho-ku in Seoul. And Sung Mo Rhee tested the various link performance functions using the three typical delay functions i.e., HCM, Korean Transport Institute (KOTI), and TRANSYT8. In this paper, The IDUO Route Choice Model incorporating the Akcelik's standard delay formulations is applied to the real network of Seoul in order to develop the realistic link performance function to be applied to the dynamic route choice model.


AB We describe part of the framework of the TRANSIMS traffic research project at the Los Alamos National Laboratory. It includes parallel implementations of a route planner and of a microscopic traffic simulation, and iterative re-planning for dynamic route assignment. The parallel implementation uses domain decomposition and an adaptive load-balancing scheme. We present performance figures for street networks.
with up to 20,000 links, and estimates for much larger networks, as will be used for the next TRANSIMS case study.


The study presents an approach by adapting the probabilistic multipath assignment model to the case of non-stationary input flows. Given non-stationary input flows, the assignment model evaluates for each point of the transportation network. The flow distribution through time. This allows to study the formation and evolution of congestion and gives a more precise image of the reality. The algorithm implementing this dynamic model uses repeatedly an adapted version of the algorithm for the stationary case and a fast Fourier transform procedure.


We discuss topics related to the notion of shortest paths in large street networks. In the first part, we discuss the dynamic traffic assignment problem and describe an algorithm designed to determine user equilibria in simulation-based traffic models. The proposed algorithm is able to find in a reasonable amount of time equilibria in problems that are not treatable with conventional methods (e.g., Frank-Wolfe algorithm). The second part deals with an improved algorithm to find shortest paths in street networks with given link cost functions. The main idea is to reduce the network using the intrinsic properties of street networks and to perform a (backward) Dijkstra-algorithm on this reduced network. This approach results in a highly accurate algorithm which is faster than the straightforward approach by a factor of 4.


The purpose of this paper is to present two improved numerical algorithms for the continuous dynamic network loading problem. These methods, which may be considered to be event-based simulations, represent a major improvement over the functional equations approaches which was developed by Wu et al. [Transportation Research 32 (1998) 173] and the solution method given by Xu et al. [Transportation Science 33 (1999) 341]. Computational results are given for the loading methods and their use as a subproblem in an algorithm for dynamic traffic assignment.


The analytical approaches to dynamic traffic assignment did not consider until now the limited capacity of arcs. In this paper a model and an algorithm are developed for this problem. The method was coded and computational results were obtained.


One of the main components of stochastic assignment models is the route choice model solved with implicit or explicit path enumeration algorithms. Such models are used both for congested networks within equilibrium or dynamic models and for non-congested networks within static or pseudo-dynamic network loading models. This paper proposes a C-Logit model specification within a Dial algorithm structure for the implicit assignment of network flows. The model and its solution algorithm, called D-C-Logit, combine several positive features found in the literature for choice set generation and choices from a given choice set: generation of a set of alternatives with a selective approach; calculation of the path choice probability in a closed form; simulation of the overlapping effect among alternative paths; computation of just one tree for each origin avoiding explicit path enumeration. This paper has two main objectives: the proposition of a Dial-like
algorithm to solve a C-Logit assignment model and application of the algorithm to different networks in order to demonstrate certain properties.


AB Existing transportation planning modeling tools have critical limitations with respect to assessing the benefits of intelligent transportation systems (ITS) deployment. In this article, we present a novel framework for developing modeling tools for quantifying ITS deployments benefits. This approach is based on using case-based reasoning (CBR), an artificial intelligence paradigm, to capture and organize the insights gained from running a dynamic traffic assignment (DTA) model. To demonstrate the feasibility of the approach, the study develops a prototype system for evaluating the benefits of diverting traffic away, from incident locations using variable message signs. A real-world network from the Hartford area in Connecticut is used in developing the system. The performance of the prototype is evaluated by comparing its predictions to those obtained using a detailed DTA model. The prototype system is shown to yield solutions comparable to those obtained from the DTA model, thus demonstrating the feasibility of the approach.


AB With the recent advances in communications and information technology, real-time traffic routing has emerged as a promising approach to alleviating congestion. Existing approaches to developing real-time routing strategies, however, have limitations. This study examines the potential for using case-based reasoning (CBR), an emerging artificial intelligence paradigm, to overcome such limitations. CBR solves new problems by reusing solutions of similar past problems. To illustrate the feasibility of the approach, the study develops and evaluates a prototype CBR routing system for the interstate network in Hampton Roads, Virginia. Cases for building the system's case-base are generated using a heuristic dynamic traffic assignment (DTA) model designed for the region. Using a second set of cases, the study evaluates the performance of the prototype system by comparing its solutions to those of the DTA model. The evaluation results demonstrate that the prototype system is capable of running in real-time, and of producing high quality solutions using case-bases of reasonable size.


AB Real-time traffic flow management has recently emerged as one of the promising approaches to alleviating congestion. This approach uses real-time and predicted traffic information to develop routing strategies that attempt to optimize the performance of the highway network. A survey of existing approaches to real-time traffic management indicated that they suffer from several limitations. In an attempt to overcome these, the authors developed an architecture for a routing decision support system (DSS) based on two emerging artificial intelligence paradigms: case-based reasoning and stochastic search algorithms. This architecture promises to allow the routing DSS to (a) process information in real time, (b) learn from experience, (c) handle the uncertainty associated with predicting traffic conditions and driver behavior, (d) balance the trade-off between accuracy and efficiency, and (e) deal with missing and incomplete data problems.


AB Real-time traffic management is a promising approach for alleviating congestion. This approach uses real-time and predicted traffic information to develop routing strategies that optimize the performance of highway networks. This article explores the potential for using case-based reasoning (CBR), an emerging artificial intelligence (AI) paradigm, to overcome the limitations of existing traffic-management decision support systems. To illustrate the feasibility of the approach, the article develops and evaluates a prototype CBR routing system for a real-world network in Hampton Roads, Virginia. Cases for building the system's case
base are generated using a heuristic dynamic traffic assignment (DTA) model specifically designed for the
region. Using a set of 25 new independent cases, the performance of the prototype system is evaluated by
comparing its solutions with those of the DTA model. The evaluation results demonstrate the feasibility of the
CBR approach. The prototype system was capable of running in real time and produced high-quality solutions
using case bases of reasonable size.

traffic assignment program with recourse for incident traffic management. Transportation Research Record

AB Robust real-time traffic management methodologies are needed to respond to freeway congestion caused
by unexpected incidents. A multistage stochastic mathematical model with recourse is introduced to compute
and disseminate real-time traffic control actions, which account for system uncertainties such as demand
variation and incident severity. The benefits include the provision of a priori robust traffic control actions that
are ideal under all circumstances of system uncertainties across all considered time periods, with significant
reduction in the online computational effort. As a result, more insights on the relationship between traffic
control actions and network properties across time periods are obtained.

Fourteenth Annual Acm-Siam Symposium On Discrete Algorithms (14th Annual ACM-SIAM Symposium
on Discrete Algorithms), 86-87.

involvement in radio information broadcasting. Transportation Planning and Technology 23, 21-35.

AB The availability of information and its form can exert an important influence over travel behavior. There
are now an increasing number of systems available to provide information on road conditions to automobile
drivers and truckers although in most cases there is still a strong reliance on radio information. Increasingly the
issue is less one of developing a new technology to disseminate traffic information and more one of modifying
institutions and behavior. In terms of behavior, there is still considerable inertia in terms of taking up modern
information systems which may be rationalized in some cases because systems have been poor in the past,
often giving late or inappropriate information. Institutionally, therefore, there is the issue of delivery. This
study is concerned with looking at the potential for greater commercial involvement in providing traffic
information particularly to leisure travelers. It looks at a case study in northern Virginia that explores the
possible involvement of commercial radio in offering information on the Interstate-gl corridor. The analysis is
based upon an interview survey of road users questioning them on the attributes they seek from information
radio traffic information sources. The specific aim being to see if there exists sufficient interest in a combined
entertainment/information channel to attract commercial interest. The overall conclusion is that while many
travelers are regular users of the corridor they do supplement their experiences from information systems and
that there is some scope for introducing combined entertainment/traffic information channels.

Transportation Research 35B, 217-235.

AB In this paper, we propose a parametric optimization approach to estimate time-dependent path flows, or
origin-destination (OD) trip tables, using available data on link traffic volumes for a general road network. Our
model assumes knowledge of certain time-dependent link flow contribution factors that are a dynamic
generalization of the path-link incidence matrix for the static case. A least squares model is accordingly
formulated to determine the time-dependent trip tables. We develop a column generation approach that uses a
sequence of dynamic shortest path subproblems in order to solve this problem. Computational results are
presented on several variants of two sample test networks from the literature.

**AB** The platoon dispersion factor is integrated into an analytical dynamic traffic assignment (DTA) model. The objective of integrating platoon dispersion with DTA is to improve the representation of flow propagation in the DTA model and enforce the first in, first out constraints. A set of new linear formulations for flow propagation that include explicit constraints on the movement of traffic in a transportation network is presented. Based on the numerical examples, it can be demonstrated that platoon dispersion is realized in an analytical DTA model by using the existing solution algorithm.


**AB** This paper presents a unified approach for improving travel demand models through the application and extension of supernetwork models of multi-dimensional travel choices. Proposed quite some time ago, supernetwork models solved to stochastic user equilibrium can provide a simultaneous solution to trip generation, distribution, mode choice, and assignment that is consistent with disaggregate models and predicts their aggregate effects. The extension to incorporate the time dimension through the use of dynamic equilibrium assignment methods is proposed as an enhancement that is necessary in order to produce realistic models. A variety of theoretical and practical problems are identified whose solution underlies implementation of this approach. Recommended future research includes improved algorithms for stochastic and dynamic equilibrium assignment, new methods for calibrating assignment models, and the use of Geographic Information Systems (GIS) technology for data and model management.


**AB** Suppose that a road network model is given, together with some given demand for travel by (say) car and that the demand for travel varies with time of day but not from day to day. Suppose that this demand is given in the form of specified total outflow rates from each origin headed towards each destination, for each origin-destination pair and for each time of day, and that some initial time-dependent route-inflow rates, meeting the given demand, are given. Finally, suppose that within-day time is represented by a continuous variable. This paper specifies a natural smooth day-to-day route-swapping procedure wherein drivers swap toward less expensive routes as day succeeds day, and shows that under reasonable conditions there is an equilibrium state of this dynamical system. If such a collection of route-inflows has arisen today, say, then there is no incentive for any route-inflow to change tomorrow, in the sense that at each moment of today each of today's route-inflows is already on a route which today yielded the smallest travel cost. Such a set of "no-incentive-to-change" route-inflows is called a dynamic equilibrium, or a dynamic user-equilibrium, and may be regarded as a solution of the dynamic equilibrium traffic assignment problem. Thus, the paper introduces a smooth day-to-day dynamic assignment model and, using this model, shows that there is a dynamic user-equilibrium in a continuous time setting. The paper briefly considers the day-to-day stability of the route-swapping process, also in a continuous setting. Finally, the paper gives a simple dynamical example illustrating the stability of the route-swapping process in a simple two-route network when there is deterministic queueing at bottlenecks.


**AB** This paper presents a new dynamic model of peak period traffic flows on congested capacity-constrained urban road networks. While respecting the first in, first out (FIFO) discipline of road traffic queues and the exit capacities of road links, the model determines the (time-varying) costs incurred in traversing the various routes when (time-varying) route inflows are specified. It is proved that if this model is used to find route costs then a dynamic user equilibrium exists. The paper also gives four optimisation formulations of the dynamic user equilibrium problem. A descent algorithm is suggested; there is, as yet, no proof that the algorithm converges to an equilibrium. Finally, the paper introduces a family of alternative methods of determining dynamic flows which (almost) satisfy FIFO, and specifies one member of this family in some detail. These alternative methods arise as a consequence of using different ways of specifying the priority of a vehicle or a group of vehicles.
AB Traffic assignment is a procedure for estimating the distribution of traffic over a transportation system under specified conditions. Traffic assignment may thus be used for estimating the likely impact of proposed physical changes to an urban road network, and so to aid the design of beneficial changes. It is also natural to use traffic assignment if a traffic control system or a road pricing system is to be either assessed or designed. Current traffic assignment tools are unable to deal with the detailed dynamic interactions between different traffic flows over large networks, and so it is currently impossible to estimate reliably the likely network-wide effects of proposed new traffic control methods or of proposed new road pricing schemes (for example), at least for large networks. In this paper we outline work currently being undertaken at the University of York, aimed at the development of an extremely fast and smooth dynamic assignment method. The new method is based on natural route-swapping rules, with drivers swapping from more to less expensive routes as day succeeds day. The method is designed so as to be well-suited to implementation on parallel computing machines and also so that control strategies naturally fit the detailed framework. The aim is to utilize a parallel implementation of a natural route-swapping process so as to produce an extremely fast and accurate dynamic assignment tool which is able to design and assess control or pricing strategies on large networks. The paper is an expansion of Smith and Wisten and may also be regarded as a continuation of the papers by Smith and Ghali, and Bernstein, Friesz, Tobin and Wie on continuous dynamic equilibrium models. The paper gives a computational result which illustrates the convergence to equilibrium of our natural route-swapping process in a simple example and a link-flow formulation of the dynamic equilibrium assignment problem.


AB The paper considers traffic assignment, with traffic controls, in an increasingly dynamic way. First, a natural way of introducing the responsive policy, P(o), into steady state traffic assignment is presented. Then it is shown that natural stability results follow within a dynamical version of this static equilibrium model (still with a constant demand). We are able to obtain similar stability results when queues are explicitly allowed for, provided demand is constant. Finally we allow demand to vary with time; we consider the dynamic assignment problem with signal-settings now fixed. Here we assume that vehicles are very short and that deterministic queueing theory applies, and show that the time-dependent queueing delay at the bottleneck at the end of a link is a monotone function of the time-dependent input profile to the bottleneck. We have been unable to obtain results when dynamic demand and responsive signal control are combined.


AB This paper considers a dynamic model of traffic assignment in which drivers change their route choices to take advantage of cheaper routes. Using a method due to Lyapunov, we show that if the cost-flow function is monotone and there are no explicit capacity restrictions then any solution trajectory of the dynamical system converges to the set of J. G. Wardrop equilibria as time passes.


AB This paper examines a methodological framework for improving the estimation of current and future O-D demand matrices. The problem of O-D matrix estimation is investigated for the case of extended urban transport networks, where the topological complexity and high variability of the prevailing traffic conditions result in the rapid degradation of the information concerning the underlying O-D demand patterns. The paper aims to contribute to the development of a set of analytical tools for interpreting the loss of the resulting O-D matrix reliability and the extent and sources of the information degradation. The suggested framework treats in an appropriate way the short-term systematic variations of prior demand information and, hence, increase the
consistency and predictability of the within-day time-dependent O-D matrices. In addition, it takes into account the long-term dynamics underlying the degradation of O-D information by means of equilibrium analysis of the evolving O-D flows over a series of day-of-the-week. In this way, changes in the reliability thresholds of current O-D matrices may be estimated to enhance the predictability of daily demand flows.


AB The existing literature on departure-time choice has primarily focused on work trips. Departure-time choice for nonwork trips, which constitute an increasingly large proportion of urban trips, is examined. Discrete choice models are estimated for home-based social/recreational and home-based shopping trips using the 1996 activity survey data collected in the Dallas-Fort Worth metropolitan area. The effects of individual and household sociodemographics, employment attributes, and trip characteristics on departure-time choice are presented and discussed. The results indicate that departure-time choice for social/recreational trips and shopping trips is determined for the most part by individual or household sociodemographics and employment characteristics, and to a lesser extent by trip level-of-service characteristics. This suggests that departure times for social/recreational and shopping trips are not as flexible as one might expect and are confined to certain times of day because of overall scheduling constraints. Future methodological and empirical extensions of the current research are identified.


AB This technical note proposes a method for quasi-dynamic traffic assignment on the basis of the commuters' departure time choice model responding to en-route traffic congestion, which has been previously proposed. The proposed method uses super-networks spaced corresponding to the departure time selection. The proposed method is based on the structure of the departure time choice model and it provides a basis for calculating quasi-dynamic traffic assignments under various situations.


AB This paper reviews a variety of traffic assignment models, including static, dynamic, system optimization, and user equilibrium models. Model characteristics are introduced, and the strengths and shortcomings of the models are discussed. The potential for application within ITS is also considered.


AB In this paper, a predictive dynamic traffic assignment model in congested capacity-constrained road networks is formulated. A traffic simulator is developed to incrementally load the traffic demand onto the network, and updates the traffic conditions dynamically. A time-dependent shortest path algorithm is also given to determine the paths with minimum actual travel time from an origin to all the destinations. The traffic simulator and time-dependent shortest path algorithm are employed in a method of successive averages to solve the dynamic equilibrium solution of the problem. A numerical example is given to illustrate the effectiveness of the proposed method.

A traffic assignment model was constructed to generate dynamic user-optimal routes for all trips in a congested capacity-constrained road network. The space-time network model was formulated consisting of nodes and links in which spillbacks and delays based on a first-in-first-out queuing discipline are captured explicitly. In this model, links are constrained by a spatial capacity governed by a specified jam density. If this spatial capacity is not exceeded or if the link is not closed, vehicles travel at a speed which is dependent on the instantaneous vehicle density, otherwise vehicles are spilled back to an upstream link. By recording the cumulative arrival and departure patterns at a link, time-dependent queuing delays can be estimated.


In designing an improved highway network, it is useful to predict traffic congestion under various settings. In particular, a dynamic flow model is suitable for a highly congested road network during the morning rush-hour. In the literature on dynamic traffic assignment models, however, attention has been paid for the most part to a single-destination network so far. The purpose of this paper is to propose a multicommodity dynamic flow model for predicting traffic congestion on a multidestination network. The model is formulated as an equilibrium programming problem, the solution of which represents a 'commodity optimizing' flow pattern in the network. The problem consists of a set of convex programming subproblems and each subproblem amounts to minimizing the total cost for the users having a common destination. Existence of an equilibrium flow pattern is established under appropriate conditions and an algorithm for computing it is described.


In order to select a model for application in Ontario's freeway-arterial corridors, a review of potential candidates was performed. The criteria for evaluating suitable alternatives included the quality of the path selection technique, the ability to represent dynamic queueing effects, the accuracy and detail of the traffic flow model, and the resolution of the traffic signal representation on parallel arterials. On the basis of a literature review and a preliminary evaluation of fundamental requirements, some of the initial models were found to be clearly incompatible with the objective of modeling dynamic assignment and queueing in freeway-arterial corridors. However, it appeared that some could potentially be upgraded, given that a considerable amount of further development effort was applied. In this respect, CONTRAM and CORQ appeared most promising because of their superior queueing-based assignment techniques and their treatment of time varying queues and demands.


Commuters may react to structural congestion on urban roads and freeways by adjusting their departure time. Single-bottleneck models enable direct insight into the mechanisms of departure time choice. The interaction of user equilibrium departure time choice processes for multiple user classes in continuous time is studied in the situation in which all users have to pass a common bottleneck. The study draws on the bottleneck approach introduced by Vickrey and provides a generic algorithm that solves the departure time choice equilibrium problem given heterogeneous departure time preferences, arbitrary origin-bound and destination-bound rescheduling cost functions, and arbitrary queuing cost functions. For all user classes, the (generalized) queuing costs have a travel duration-dependent component and a travel cost-dependent component. First, a solution is provided for the elastic-demand case. It is shown that the equilibrium departure rates per user class can be calculated directly by calculating the acceptable travel times per user class. Second, a solution is provided for the fixed-demand case. The fixed-demand problem is formulated as a minimization problem that is solved using the Nelder-Mead procedure. The algorithm is illustrated with an example showing the effects of a flat peak-hour road pricing scheme on the departure time choice and total incurred costs per user class.

AB As congestion results not only in the dispersion of origin-destination (O-D) demand across multiple routes but also in peak spreading, use of dynamic traffic assignment models as a means of predicting the impact of a new infrastructure should take into account departure time choice in addition to route choice. Departure time choice may be modeled simultaneously with route choice. In such a model, each traveler has a preferred departure and arrival time, deviation from which results in a certain disutility. Departure time choice can be viewed as route choice in a suitably defined hypernetwork. The combination of departure time choice and route choice in a single framework is called the dynamic user optimum departure and route choice (DUO-D&R) assignment. When the DUO assignment needs a dynamic O-D matrix with fixed departure times, the DUO-D&R assignment needs a dynamic O-D matrix with preferred departure times. This matrix is called the preferred departure time O-D (pOD) matrix. A method is proposed for estimating the pOD demand matrix that reflects preferred instead of realized departure times. To carry out this estimation, the DUO-D&R problem is formulated and solved. The schedule delay function and the departure choice model are assumed to be known. The possible advantage of the DUO-D&R assignment over DUO assignment is demonstrated through numerical experiments that correspond to scenarios in which infrastructure is expanded and travel demand is subject to uniform growth.


AB This article presents some theoretical developments that have resulted in a dynamic traffic forecasting procedure that is feasible both from a technical viewpoint (data availability) and from a practical viewpoint (data preparation). The procedure consists of a dynamic origin-destination (OD) matrix estimation module and a dynamic traffic assignment module. The OD-estimation module is an extension of traditional (static) OD-estimation methods, i.e. production-attraction models combined with the use of a deterrence function. To make the procedure computationally feasible an efficient parameter estimation method has been provided. To test the combined OD-estimation/dynamic assignment model, data were collected continuously during 3 weeks at 141 locations on the beltway of Amsterdam. As an alternative to the proposed procedure, historical averages have been compiled from all observed data. Comparisons between true, predicted and averaged data show that a lot of effort must be invested in specifying OD-demand and network characteristics in order for the new method to be competitive with historic averages for traffic forecasting. Exceptional circumstances such as severe incidents, however, are reported better with the dynamic forecasting procedure.


AB Basically a route guidance system consists of an in-vehicle display unit, a central control unit and communications links between these. The traffic model in the central computer will play a vital role in the ultimate success of the guidance system. Four of the modelling issues, related to traffic assignment, are addressed. The paper concentrates on dynamic electronic route guidance systems, such as AUTOGUIDE and ALI-SCOUT, as opposed to systems that concentrate on map display. The discussion turns on the question of who would benefit most from a guidance system: the submembers or community. The reality value of assignment models, dynamic assignment, and the problems of signal control and assignment are discussed. The need for realistic assignment models, an explicit consideration of time in the models, and the combined optimisation of signals and routes, is indicated. All three, in a user equilibrium context, give rise to non-convex, non-linear programming problems, for which no fast, convergent solution algorithms are known. Three ways to overcome this are indicated.

A system to identify all left turns, through movements, and right turns at a signalized intersection is described. The complete system requires detection of vehicle departures from the intersection, right turn detection, and information on present phasing from the signal controller. The system is demonstrated with videotape data for one departure leg of a signalized intersection. Actual vehicle movements are compared to both a manual application of the algorithm and an application using a wide area detection system (WADS). The manual application indicated that the algorithm should correctly reflect vehicle movements. The WADS application also supported the feasibility of the system. The information from such a system could be used to improve the information component of real-time traffic adaptive signal control systems, dynamic traffic assignment, and estimates of origin-destination matrices.


The paper adopts the framework employed by the existing dynamic assignment models, which analyse specific network forms, and develops a methodology for analysing general networks. Traffic conditions within a link are assumed to be homogeneous, and the time varying O-D travel times and traffic flow patterns are calculated using elementary relationships from traffic flow theory and link volume conservation equations. Each individual is assumed to select a departure time and a route by trading off the travel time and schedule delay associated with each alternative. A route is considered as reasonable if it includes only links which do not take the traveller back to the origin. The set of reasonable routes is not consistent but depends on the time that an individual decides to depart from his origin. Equilibrium distributions are derived from a Markovian model which describes the evolution of travel patterns from day to day. Numerical simulation experiments are conducted to analyse the impact of different work start time flexibilities on the time dependent travel patterns. The similarity between link flows and travel times obtained from static and dynamic stochastic assignment is investigated. It is shown that in congested networks the application of static assignment results in travel times which are lower than the ones predicted by dynamic assignment.


The continuous network design problem that occurs when the origin-destination time-dependent demands are random variables with known probability distributions is described. A chance-constraint and two-stage linear programming formulation are introduced based on a system optimum dynamic traffic assignment model that propagates traffic according to the cell transmission model. The introduced approaches are limited to continuous link improvements and do not provide for new link additions. The chance-constrained model is tested on an example network that resembles a freeway corridor to demonstrate the simplicity and applicability of the approach. Initial results suggest that planning for an inflated demand may produce benefits in terms of system performance and reduced variance.


In this dissertation, the model of bi-level optimization of dynamic traffic assignment has been presented. This model makes dynamic system optimum under the precondition of ensuring dynamic user optimum. In other words, it makes the travel fee in the system as cheap as possible, while reducing every user cost. As we set up the theoretic model of dynamic traffic assignment, we consider the optimization of the traveler's route as the basic element. We consider not only the travel impedance of the vehicle but also the delay in the traffic queue caused by signal control in the intersection. After setting up the model of the bi-level dynamic traffic assignment, the authors give the algorithm.

AB Traffic flow simulation and user-optimal dynamic traffic assignment (DTA) in complex freeway networks are considered. For the DTA calculation, feedback laws of the bang-bang, proportional, proportional plus integer (PI) types, and iterative algorithms that use Frank-Wolfe or PI updating formulas are investigated. Recently, METANET, a macroscopic simulation program for freeway networks, was extended to include generic feedback DTA calculation, whereas METANET-DTA, a new METANET derivative, which uses iterative DTA calculation, was developed. Respective program structures and DTA functions are described. Simulation results demonstrate the DTA functions of extended METANET and METANET-DTA.


AB Existing models of stochastic network equilibrium route choice in transport networks are able to represent exogenously specified variations in drivers' actual or perceived travel costs, but assume throughout that flows are deterministic. In this paper, a new notion of equilibrium is presented based on stochastic flow variables, in which the impact of variable flows on the variability in travel costs is endogenously handled. Firstly, a very general notion of equilibrium is deduced as a fixed point condition on the joint probability distribution of network flows. Then, an approximation to this condition is derived, which operates by equilibrating moments of order n and below of the joint flow probability distribution, and is termed a Generalized Stochastic User Equilibrium of order n, being denoted GSUE(n). The GSUE(1) model is seen to be a conventional Stochastic User Equilibrium. The paper goes on to focus on the second order model, GSUE(2). Conditions are presented to guarantee the existence of GSUE(2) solutions. Conditions are deduced to guarantee (a) uniqueness of solutions in networks with a single interzonal movement, and (b) proximity of solutions in networks with multiple interzonal movements. Finally, a simple example is presented.


AB Real traffic networks typically exhibit considerable day-to-day variations in traffic flows and travel times, yet these variations are commonly neglected in network performance models. Recently, two alternative theoretical approaches were proposed for incorporating stochastic flow variation in the equilibration of route choices: the stochastic process (SP) approach (Cantarella and Cascetta 1995) and the second order generalized stochastic user equilibrium (GSUE(2)) model (Watling 2002). The theoretical basis of the two approaches is contrasted, and the paper goes on to present a heuristic solution method for the GSUE(2) model, and two alternative simulation methods for the SP model, each applicable to the realistic case of probit-based choice probabilities. These solution methods are then applied to two realistic networks. Factors affecting convergence and reproducibility are first identified, followed by comparisons of the GSUE(2) and SP predictions. It is seen that a quasi-periodic behaviour commonly arises in the SP model, with the predictions radically different from the GSUE(2) model. However, by modifying the link performance functions in the overcapacity regime, the nature of the SP solution changes, and for a memory filter based on a large number of days' experience, its moments are seen to be approximated by those of the GSUE(2) model. Implications for the application of these models are discussed.


AB The question of whether plausible dynamical adjustment processes converge to equilibrium was brought to attention by the compelling analysis of Horowitz, J. L., 1984. The stability of stochastic equilibrium in a two link transportation network. Transportation Research 18B (1), 13-28. His analysis of discrete time processes, and the question of their convergence to stochastic equilibrium, had the significant restriction of applying only
to two-link networks. In spite of a number of significant works on this 'stability' issue since, the extension of Horowitz's results to general networks has still not been achieved, and this forms the motivation for the present paper. Previous analyses of traffic assignment stability are first reviewed and classified. The key, and often misunderstood, distinctions are clarified: between stability in discrete time and continuous time, and between stability with respect to deterministic and stochastic processes. It is discussed how analyses since Horowitz's characterise much milder notions of stability. A simple dynamical adjustment process is then proposed for studying the stability of the general asymmetric stochastic equilibrium assignment problem in discrete time. Classical techniques from the dynamical systems literature are then applied in three ways, resulting in: a sufficient condition for stability, applicable to a significant subset of practical problems; a widely-applicable sufficient condition for instability; and a method for estimating domains of attraction for problems with multiple equilibria. The tests are illustrated in relation to a number of simple examples. In principle, they are applicable to networks of an arbitrary size, although further tests would be required to determine the computational feasibility of these techniques in large networks.


A number of results are established regarding the stability of the asymmetric stochastic equilibrium assignment model for general networks. In particular, we consider the marginal effect of any swap of flow from one route to an alternative, under various behavioural rules describing the way in which drivers integrate their perceived costs at equilibrium with those in disequilibrium. These pairwise route how swaps are referred to as 'perturbations', since they assume that other route flows are held at their equilibrium levels (even though it is a non-local property, in the sense that the size of the flow swap is only limited by the demand-feasibility constraints). Loosely speaking, an equilibrium is then said to be stable if following any such perturbation, there is an incentive for drivers to re-route in the direction or the same equilibrium. It is seen that if the route choice is described by a random utility model and the cost functions are monotone, then equilibrium is stable with respect to some behavioural adjustment assumptions, and unstable with respect to others. If, alternatively, the cost functions satisfy a certain derivative condition, we show that stability may be established with respect to a greater range of behavioural adjustments. By studying the limiting case as the perception error variance matrix tends to zero, it is shown that these concepts of stability may be regarded as generalisations of the 'equilibration' concept of stability proposed for deterministic equilibrium. Finally, simple examples are used to explore the application of the theorems above to study local properties of problems with multiple stochastic equilibria.


There is a spectrum of asymmetric assignment problems to which existing results on uniqueness of equilibrium do not apply. Moreover, multiple equilibria may be seen to exist in a number of simple examples of real-life phenomena, including interactions at priority junctions, responsive traffic signals, multiple user classes, and multi-modal choices. In contrast, recent asymptotic results on the stochastic process approach to traffic assignment establish the existence of a unique, stationary, joint probability distribution of flows under mild conditions, that include problems with multiple equilibria. In studying the simple examples mentioned above, this approach is seen to be a powerful tool in suggesting the relative, asymptotic attractiveness of alternative equilibrium solutions. It is seen that the stationary distribution may have multiple peaks, approximated by the stable equilibria, or a unimodal shape in cases where one of the equilibria dominates. It is seen, however, that the convergence to stationarity may be extremely slow. In Monte Carlo simulations of the process, this gives rise to different types of pseudo-stable behaviour (flows varying in an apparently stable manner, with a mean close to one of the equilibria) for a given problem, and this may prevail for long periods. The starting conditions and random number seed are seen to affect the type of pseudo-stable behaviour over long, but finite, time horizons. The frequency of transitions between these types of behaviour (equivalently, the average sojourn in a locally attractive, pseudo-stable set of states) is seen to be affected by behavioural
parameters of the model. Recommendations are given for the application of stochastic process models, in the light of these issues.


AB The potential for using advanced technology to influence traffic movement and travel behaviour has generated a massive interest throughout the developed world. In-vehicle, dynamic driver information and dynamic route guidance systems have probably attracted the most attention, with many research activities and field trials planned or currently in progress. Network simulation models have a key role to play, both in assessing the potential benefits (in order to justify the initial investment) and in determining the best means of implementation. There are many who believe that existing models are deficient in a number of ways for evaluating such strategies, and a number have sought to develop new approaches. However, it takes a great many years for a new network model to be fully developed, tested, validated and accepted in the practical world. This review article has three main objectives. First, a review of the state-of-the-art in existing network models is given, with respect to their ability to meet the main requirements for modelling dynamic driver information systems. This is intended to aid practitioners in selecting a model now for their own particular strategy and objectives. The modelling requirements have been identified from a survey of demonstration projects, laboratory experiments and attitudinal studies in this area. Secondly, recent and on-going research in the network modelling area is reviewed, particularly with respect to the increased understanding of the requirements for simulating dynamic driver information systems which has arisen over the past five years. The intention here is to assess whether current research activities are addressing the full range of issues and whether resources are being appropriately divided. Finally, arising from these reviews, future research directions and priorities are identified.


AB A lane-assignment model in a vehicle-based microscopic simulation system describes a vehicle's position during its journey on an urban street network. In other words, it is used to estimate an individual vehicle's location, speed, routing plan, lane-choice plan, lane-changing plan, and car-following plan from its entrance to a street network until the end of the trip. From the authors' observations and study of lane-choice and lane-changing behavior, it is concluded that a vehicle is assigned to a lane in a logical manner depending on the relationship between its route-planned motivation and traffic conditions in the current lane and other lanes. A lane-assignment model consists of three components: lane choice, car following, and lane-changing behavior, it is concluded that a vehicle is assigned to a lane in a logical manner depending on the relationship between its route-planned motivation and traffic conditions in the current lane and other lanes. A lane-assignment model consists of three components: lane choice, car following, and lane changing. The lane-changing component is composed of three submodels-a decision model, a lane-changing condition model, and a lane-changing maneuver model. Rules are discussed for lane-choice and lane-changing modeling based on videotaped observations over four-lane urban streets. Then a heuristic structure of a lane-vehicle-assignment model is proposed, which exposes the inherent relationship between vehicle-based travel behavior and lane-vehicle assignment on an urban street network. With the addition of a lane-assignment model derived from observed data, a simulation may be developed to correctly represent travel behavior and dynamic traffic assignment at the lane level and provide a more effective tool for design and evaluation of the performance of strategies for traffic control, traveler information, and congestion alleviation.


AB In this paper, a dynamic user equilibrium traffic assignment model with simultaneous departure time/route choices and elastic demands is formulated as an arc-based nonlinear complementarity problem on congested traffic networks. The four objectives of this paper are (1) to develop an arc-based formulation which obviates the use of path-specific variables, (2) to establish existence of a dynamic user equilibrium solution to the model using Brouwer's fixed-point theorem, (3) to show that the vectors of total arc inflows and associated
minimum unit travel costs are unique by imposing strict monotonicity conditions on the arc travel cost and demand functions along with a smoothness condition on the equilibria, and (4) to develop a heuristic algorithm that requires neither a path enumeration nor a storage of path-specific flow and cost information. Computational results are presented for a simple test network with 4 arcs, 3 nodes, and 2 origin-destination pairs over the time interval of 120 periods.


AB We develop a numerical method to solve the user equilibrium simultaneous departure time and route choice problem on congested general traffic networks. This method is based on the diagonalization algorithm which has been used to solve general variational inequalities. The diagonalized problem is solved using the Frank-Wolfe method. Computational results are presented for a test network with 76 arcs, 24 nodes and 528 origin-destination pairs over the time interval of 120 periods. The improved accuracy of the diagonalization algorithm is demonstrated through numerical comparisons to an approximate solution obtained by the heuristic algorithm. The CPU time spent by each algorithm is also compared to demonstrate that the diagonalization algorithm converges to a more accurate equilibrium solution significantly faster than the heuristic algorithm.


AB In this paper, a dynamic system-optimal traffic assignment model is formulated as a convex control problem for a congested general network with many origins and many destinations. Analytical and computational difficulties caused by the nonconvexity of the previous models are eliminated. The modeling of arc traffic dynamics is improved to prohibit instantaneous flow propagation on each arc even though the concave exit functions are still employed to represent the physical process of traffic congestion. An economic interpretation of the optimality conditions is given as a dynamic assignment principle which requires equilibration of actual marginal costs on all the paths that are used. A numerical example is also presented.


AB The problem of a dynamic Nash equilibrium traffic assignment with schedule delays on congested networks is formulated as an N-person nonzero-sum differential game in which each player represents an origin-destination pair. Optimality conditions are derived using a Nash equilibrium solution concept in the open-loop strategy space and given the economic interpretation as a dynamic game theoretic generalization of Wardrop's second principle. It is demonstrated that an open-loop Nash equilibrium solution converges to an instantaneous dynamic user equilibrium solution as the number of players for each origin-destination pair increases to infinity. An iterative algorithm is developed to solve a discrete-time version of the differential game and is used to numerically show the asymptotic behavior of open-loop Nash equilibrium solutions on a simple network. A Nash equilibrium solution is also analyzed on the 18-arc network.


AB In this paper we develop two types of dynamic congestion pricing model, based on the theory of marginal cost pricing. The first model is appropriate for situations where commuters have the ability to learn the best route choices through day-to-day explorations on a network with arc capacities and travel demands that are stable from day to day. The second model is appropriate for situations where commuters optimize their routing decisions each day on a network with arc capacities and travel demands that fluctuate significantly from day to day. We show that two types of time-varying congestion tolls can be determined by solving a convex control formulation of the dynamic system optimal traffic assignment problem on a network with many origins.
and many destinations. We also show that the dynamic system optimal traffic assignment is an equilibrium for commuters under the tolls in both cases.


AB One way to estimate the potential benefits of new traffic control and management systems is to compare the total cost incurred in equilibrium with the system optimized total cost. To do this, we formulate the dynamic traffic assignment models with schedule delays under the system optimum and user equilibrium principles and solve them using numerical methods. System optimum and user equilibrium dynamic assignments on an 18-arc test network are then compared in terms of total travel times and schedule delays at different levels of traffic congestion. This comparison provides important implications for the success of the intelligent transportation systems (ITS) in reducing traffic congestion.


AB The dynamic mixed behavior traffic network equilibrium model is formulated as a noncooperative N-person nonzero-sum differential game under the open-loop information structure. A simple network is considered where one origin-destination pair is connected by parallel arcs and two types of players - User Equilibrium (UE) and Cournot-Nash (C-N) - interact through the congestion phenomenon. Each of UE and C-N players attempts to achieve its own prescribed objective by making a continuum of simultaneous decisions of departure time, route, and departure flow rate over a fixed time interval. The necessary and sufficient conditions are derived and given economic interpretation as a dynamic game theoretic generalization of the mixed behavior traffic network equilibrium principle which requires equilibration of average costs for UE players and equilibration of marginal costs for C-N players. An approximate iterative algorithm is proposed for solving the model in discrete time, which makes use of the augmented Lagrangian method and the gradient method. A numerical example is presented and future extensions of the model and the algorithm are also discussed.


AB In this paper we formulate the dynamic network user equilibrium problem as a variational inequality problem in discrete time in terms of unit path cost functions. We then show how exit flow functions and nested cost operators can be used to calculate unit path costs given the departure time and route choices of network users. We also demonstrate that, assuming certain regularity conditions hold, a discrete time dynamic network user equilibrium is guaranteed to exist. Finally, a heuristic algorithm and numerical results are presented.


AB We develop and test an augmented Lagrangian method for solving dynamic traffic assignment models formulated as optimal control problems. Our presentation is in terms of the discrete time, system optimal traffic assignment problem. However, the basic ideas presented here are readily applied to continuous time models and to other behavioral assumptions regarding traffic assignment which may be expressed as optimal control problems. The proposed algorithm obviates the need for path enumeration and exploits the natural decomposition of the traffic assignment problem by time period which is possible when an optimal control formulation is employed.

AB This paper considers the problem of the competition among a finite number of players who must transport the fixed volume of traffic on a simple network over a prescribed planning horizon. Each player attempts to minimize his total transportation cost by making simultaneous decisions of departure time, route, and flow rate over time. The problem is modeled as a N-person nonzero-sum differential game. Two solution concepts are applied: [1] the open-loop Nash equilibrium solution and [2] the feedback Nash equilibrium solution. Optimality conditions are derived and given an economic interpretation as a dynamic game theoretic generalization of Wardrop's second principle. Future extensions of the model are also discussed. The model promises potential applications to Intelligent Vehicle Highway Systems (IVHS) and air traffic control systems.


AB An equivalent continuous time optimal control problem is formulated to predict the temporal evolution of traffic flow pattern on a congested multiple origin-destination network, corresponding to a dynamic generalization of Wardropian user equilibrium. Optimality conditions are derived using the Pontryagin minimum principle and given economic interpretations, which are generalizations of similar results previously reported for single-destination networks. Analyses of sufficient conditions for optimality and of singular controls are also given. Under the steady-state assumptions, the model is shown to be a proper dynamic extension of Beckmann's mathematical programming problem for a static user equilibrium traffic assignment.


AB Optimal control theory is applied to the problem of dynamic traffic assignment, corresponding to user optimization, in a congested network with one origin-destination pair connected by N parallel arcs. Two continuous time formulations are considered, one with fixed demand and the other with elastic demand. Optimality conditions are derived by Pontryagin's maximum principle and interpreted as a dynamic generalization of Wardrop's first principle. The existence of singular controls is examined, and the optimality of singular controls is assured by the generalized convexity conditions. Under the steady-state assumptions, a dynamic model with elastic demand is shown to be a proper extension of Beckman's equivalent optimization problem with elastic demand. Finally, the derivation of the dynamic user optimization objective functional is demonstrated, which is analogous to the derivation of the objective function of Beckmann's mathematical programming formulation for user equilibrium.


AB The dynamic traffic assignment problem is formulated in the space of splitting rates rather than link and route flows. A distributed algorithm for computation of dynamic user-equilibria is specified. The algorithm has been implemented on a Meiko Computing Surface with 32 T800 processors and some numerical results are given. We do not yet have a general proof of convergence for the algorithm but we have been able to demonstrate convergence with all test networks used.


AB Area traffic control is an important element in Intelligent Transportation System (ITS). This paper extends the lane-based optimization method to a traffic equilibrium network, which improves the operational performance of signal-controlled network. We formulate a decomposition approach to simultaneously optimize the lane markings and signal settings for a signal-controlled network that comprises two levels of optimization. At the junction level, the lane markings, control sequence, and other aspects of the signal settings are optimized
for individual junctions, whereas at the network level, the group-based signal settings are optimized to take into account the re-routing characteristics of travelers and signal coordination effects that are based on a TRANSYT traffic model, which is a well-known procedure for evaluating the performance of signal-controlled networks. We use a numerical example to demonstrate the effectiveness of the proposed methodology.

Wootton, JR, Garciaortiz, A, Amin, SM (2016) Intelligent transportation systems - a global perspective. Mathematical And Computer Modelling

AB Transportation has been a key element to global economic success since the days of the Egyptian pharaohs, the Chinese dynasties, and the Roman legions. In the beginning, land and water vias were the dominant transportation paradigms. With the industrial revolution came improvements in road construction, the railroad and the airplane. The ability of the latter two to move vast amounts of goods and people in a short period of time have made them the preferred long distance haul paradigms. Today, in the information age, the quest is for global economic efficiency in a world economy governed by environmental concerns, economic alliances, and trade agreements. This paper discusses some of the socio-economic factors driving the various on-going, national transportation programs. The U.S. program is used, as an example, to establish the technical and social thrusts being addressed by these programs. Each thrust is described in sufficient detail to give the reader a feel for the objectives that have been set, the accomplishments made, and the challenges that lay ahead. The evolution of intelligent transportation programs in the U.S., Japan, and Europe is also discussed.


AB In this paper, we present a long-step primal path-following algorithm and prove its global convergence under usual assumptions. It is seen that the short-step algorithm is a special case of the long-step algorithm for a specific selection of the parameters and the initial solution. Our theoretical result indicates that the long-step algorithm is more flexible. Numerical results indicate that the long-step algorithm converges faster than the short-step algorithm.


AB The continuous dynamic network loading problem aims to find, on a congested network, temporal arc volumes, are travel times, and path travel times given time-dependent path flow rates for a given time period. This problem may be considered as a subproblem of a temporal (dynamic) traffic assignment problem. In this paper, we study this problem and formulate it as a system of functional equations. Based on this system, we show that the FIFO (First In, First Out) condition is respected under a reasonable assumption. For computational purposes, we develop a polynomial approximation, which is almost equivalent to the original formulation on a set of finite discrete points. The approximation formulation is a finite dimensional system of equations which is solved as an optimization problem. The optimization problem may or may not be smooth depending on the structure of arc travel times. Several numerical examples are given to illustrate this approach.


AB The dynamic network equilibrium problem is defined as follows: find time-varying path (departure) flow rates given time dependent origin-destination departure rates for a time period on a congested network. In this paper, we propose a projection algorithm for the dynamic network equilibrium problem where we use a recent method for solving the dynamic network loading problem. A numerical algorithm is developed based on various polynomial approximations for both the continuous dynamic network loading problem and the projection iterations. Computational results are given for a small network in order to illustrate the convergent
process and the satisfaction of the O-D FIFO condition. We conclude that this algorithm is very promising and can be applied to very large networks with a long departure time period.


Recently, several interior-point methods have been developed under a scaled Lipschitz condition which may be strong in general. In this paper, we develop a modified path-following scheme which does not require the above condition. Its global convergence is proved under only the assumptions of monotonicity and differentiability of the mapping. The scheme is adapted to the network equilibrium problem (a nonlinear multicommodity network flow problem) with a simplicial decomposition technique.


We present a framework for descent algorithms that solve the monotone variational inequality problem VIP(v) which consists in finding a solution v* is-an-element-of OMEGA(v) satisfying s(v*)T(v - v*) greater-than-or-equal-to 0, for all v is-an-element-of OMEGA(v). This unified framework includes, as special cases, some well known iterative methods and equivalent optimization formulations. A descent method is developed for an equivalent general optimization formulation and a proof of its convergence is given. Based on this unified logarithmic framework, we show that a variant of the descent method where each subproblem is only solved approximately is globally convergent under certain conditions.


In this paper, we present a recurrent neural network for solving the nonlinear projection formulation. It is shown here that the proposed neural network is stable in the sense of Lyapunov and globally convergent, globally asymptotically stable, and globally exponentially stable, respectively under different conditions. Compared with the existing neural network for solving the projection formulation, the proposed neural network has a single-layer structure and is amenable to parallel implementation. Moreover, the proposed neural network has no Lipschitz condition, and, thus can be applied to solve a very broad class of constrained optimization problems that are special cases of the nonlinear projection formulation. Simulation shows that the proposed neural network is effective in solving these constrained optimization problems.


Recently, a dynamic neural system was presented and analyzed due to its good performance in optimization computation and low complexity for implementation. The global asymptotic stability of such a dynamic neural system with symmetric connection weights was well studied. This note, based on a new Lyapunov function, investigate the global asymptotic stability of the dynamic neural system with asymmetric connection weights. Since the dynamic neural system with asymmetric weights is more general than that Kith symmetric ones, the new results are significant in both theory and applications, which cover the asymptotic stability results of linear systems as special cases.


Two types of projected dynamical systems, whose equilibrium states solve the corresponding variational inequality problems, were proposed recently by Dupuis and Nagurney (Ref. 1) and by Friesz et al. (Ref. 2). The stability of the dynamical system developed by Dupuis and Nagurney has been studied completely (Ref. 3). This paper analyzes and proves the global asymptotic stability of the dynamical system proposed by Friesz et
al. under monotone and symmetric mapping conditions. Furthermore, the dynamical system is shown to be globally exponentially stable under stronger conditions. Finally, we show that the dynamical system proposed by Friesz et al. can be applied easily to neural networks for solving a class of optimization problems.


AB Linear projection equations arise in many optimization problems and have important applications in science and engineering. In this paper, we present a recurrent neural network for solving linear projection equations in real time. The proposed neural network has two layers and is amenable to parallel implementation with simple hardware. In the theoretical aspect, we prove that the proposed neural network can converge globally to the solution set of the problem when the matrix involved in the problem is positive semidefinite and can converge exponentially to a unique solution when the matrix is positive definite. In addition, we analyze the stability of the related dynamic system in detail. As an application, we show that the proposed neural network can be used directly to solve linear and convex quadratic programming problems and linear complementary problems with positive semidefinite matrices. The validity and transient behavior of the neural network are demonstrated by using three numerical examples.


AB In this paper, we present a general methodology for designing optimization neural networks. We prove that the neural networks constructed by using the proposed method are guaranteed to be globally convergent to solutions of problems with bounded or unbounded solution sets, in contrast with the gradient methods whose convergence is not guaranteed. We show that the proposed method contains both the gradient methods and nongradient methods employed in existing optimization neural networks as special cases. Based on the theoretical results of the proposed method, we study the convergence and stability of general gradient models in case of unisolated solutions. Using the proposed method, we derive some new neural network models for a very large class of optimization problems, in which the equilibrium points correspond to exact solutions and there is no variable parameter. Finally, some numerical examples show the effectiveness of the method.


AB A discrete time dynamic assignment model with simple structure for general road networks is formulated (based on what mathematical tools?) and the traffic flow conservation constraint and the dynamic equilibrium principle are satisfied under the condition of its optimal solution for the multi-origin and single destination road networks. To analyze the singularity of the optimal solution (this is novel?), the concept of complete dissimilar which links in a road network is defined and a conclusion is obtained that the optimal steady solution is strictly nonsingular. The simple and efficient algorithm (What made this method efficient? Does it mean better than the others?) for the optimal solution discussed in this paper could be applied to on line control of the large scale road networks.


AB The continuous dynamic network loading problem (CDNLP) consists in determining, on a congested network, time-dependent are volumes, together with are and path travel times, given the time-varying path flour departue rates over a finite time horizon. This problem constitutes an intrinsic part of the dynamic traffic assignment problem. In this paper, we present a formulation of the CDNLP where travel delays may be nonlinear functions of are traffic volumes. We prove, under a boundedness condition, that there exists a unique solution to the problem and propose for its solution a finite-step algorithm. Some computational results are reported for a discretized version of the algorithm.

AB The continuous dynamic network loading problem (CDNLP) consists in determining, on a congested network, time-dependent arc volumes, together with arc and path travel times, given the time varying path (departure) flow rates over a finite time horizon. This problem constitutes an intrinsic part of the dynamic traffic assignment problem. In this paper, we present a modified DYNALOAD algorithm for the continuous dynamic network loading problem. An efficient implementation is developed. Numerical examples are provided.


AB A procedure has been developed for predicting the self-assignment of time-varying traffic demands in a network. The procedure's computer program, CORQ, has been used to validate and apply the model in a real corridor. It is intended as a tool to enable the traffic analyst to assess the systemwide effects of any traffic-control strategies proposed for a network as long as the total system's demands remain invariant or at least have a predictable response to the controls. The model has been specialized to give detailed treatment to the critical elements of a corridor that affect traffic flow, capacity, queuing, and delays. It can be used for a form of microanalysis of areas that are about 500 blocks large.


AB Methods are explained which were designed to imitate effectively the assignment of traffic according to the principle where each user minimizes his own travel time. All of the methods assume a demand pattern which does not vary with time. The methods fall into the major categories of assignment by desirability only, constrained assignment, and equilibrium assignment. The first of these considers assignment of traffic to routes on the basis of their desirability, while the others take into account capacity of the link components as well as desirability of the routes. They are explained.


AB When drivers do not have complete information on road travel time and thus choose their routes in a stochastic manner or based on their previous experience, separate implementations of either route guidance or road pricing cannot drive a stochastic network flow pattern towards a system optimum in a Wardropian sense. It is thus of interest to consider a combined route guidance and road pricing system. A road guidance system could reduce drivers' uncertainty of travel time through provision of traffic information. A driver who is equipped with a guidance system could be assumed to receive complete information, and hence be able to find the minimum travel time routes in a user-optimal manner, while marginal-cost road pricing could drive a user-optimal flow pattern toward a system optimum. Therefore, a joint implementation of route guidance and road pricing in a network with recurrent congestion could drive a stochastic network flow pattern towards a system optimum, and thus achieve a higher reduction in system travel time. In this paper the interaction between route guidance and road pricing is modeled and the potential benefit of their joint implementation is evaluated based on a mixed equilibrium traffic assignment model. The private and system benefits under marginal-cost pricing and varied levels of market penetration of the information systems are investigated with a small and a large example. It is concluded that the two technologies complement each other and that their joint implementation can reduce travel time more efficiently in a network with recurrent congestion.

AB This paper deals with the modeling of peak-period congestion and optimal pricing in a queuing network with elastic demand. The approach employed in our study is a combined application of the space-time expanded network (STEN) representation of time-varying traffic how and the conventional network equilibrium modeling techniques. Given the elastic demand function for trips between each origin-destination pair and the schedule delay cost associated with each destination, the departure time and route choice of commuters and the optimal variable tolls of bottlenecks will be determined jointly by solving a system optimization problem over the STEN. Our STEN approach can deal with general queuing network with elastic demand, and allow for treatment of commuter heterogeneity in their work start time and schedule delay cost, and hence make a significant advance over the previous simple bottleneck models of peak-period congestion.


AB In this paper, a time-varying pricing model of a road bottleneck with elastic traffic demand is formulated using the optimal control theory. It is assumed that the optimal use of the bottleneck is achieved when social benefit over the whole time horizon of study is maximized. The necessary conditions for optimal solution are derived and their economic interpretations are given. Different from conventional analyses, queuing is not pre-assumed to be zero when obtaining the optimal time-varying toll, and the exit capacity of the bottleneck is assumed either to be constant or to vary with queue length. An approximate iterative algorithm is proposed for solving the model in a discrete time version. Three numerical examples are presented to demonstrate the applications of the proposed model and algorithm.


AB A dynamic model for estimating real-time origin-destination flows from time-series of traffic counts is presented. The time variation of flows is explicitly treated as a dynamic process. The model is formulated based on minimizing the integrated squared error between predicted and observed output traffic counts over the period of observation. An efficient solution method is developed by using Fourier transformation and illustrated with numerical examples. The numerical simulation experiment shows that the system dynamic approach may be particularly suitable for on-line traffic management and control in urban transportation systems.


AB Advanced traffic management systems (ATMS) and advanced traveler information systems (ATIS) are promising technologies for achieving efficiency in the operation of transportation systems. A simulation-based laboratory environment, MITSIMLab, is presented that is designed for testing and evaluating dynamic traffic management systems. The core of MITSIMLab is a microscopic traffic simulator (MITSIM) and a traffic management simulator (TMS). MITSIM represents traffic flows in the network, and the TMS represents the traffic management system under evaluation. An important feature of MITSIMLab is its ability to model ATMS or ATIS that generate traffic controls and route guidance based on predicted traffic conditions. A graphical user interface allows visualization of the simulation, including animation of vehicle movements. An ATIS case study with a realistic network is also presented to demonstrate the functionality of MITSIMLab.

Intelligent transportation systems present a well-known innovation opportunity to address urban congestion and allow greater access to transportation networks. New sources of travel information are emerging rapidly, and they are likely to significantly affect traveler decisions and transportation network performance. To assess the value and impact of these new sources, a comprehensive conceptual model is developed on the basis of information processing and traveler response. Specifically, the model accounts for the effect of information source, content, and quality on information access and travel behavior. Empirical evidence from several behavioral surveys conducted in the San Francisco Bay Area between 1995 and 1999 is presented. The surveys used innovative methods to study the response of the whole population, the response of people more inclined to use information technology (early adopters), and traveler decision making in high-benefit incident situations. The conceptual model helps to integrate and interpret empirical findings from the surveys. The issues of access to new and conventional technologies and services, their current market penetration levels, switching behavior concerning new information sources and information service providers, desired information content, and willingness to pay for dynamic information are discussed. The opportunities and limitations of new technologies and the implications for future technology implementations are described.


This paper analyses the shortcoming in calculating the length of car queue at intersection using traditional queue theory, and analyzes the principle of traffic congestion. A function of link travel time is developed according to theory of traffic flow wave. The function includes two parts, one is the car running time on non-congestion section of a link, and the other one is the delay time at downstream intersection. The method of computing car running time and the delay time is discussed.


Recently, the "Flexible work hours (FWH) system" is focused as a means to level the peak of commuting demand. However, for business activities subject to temporal agglomeration effect, the FWH system decreases the number of concurrently working people, and so the productivity is decreased, even though all workers still work for the same hours as before. This paper formulates an optimal control problem under the FWH system on motor commuting, considering one-day schedule and temporal agglomeration effect. We show that the one of the optimal distribution patterns for work start time is, some commuters start at fixed time and others start continuously before or after that fixed time. As a result, we make it clear, how could the FWH be introduced into firms to realize the optimal pattern. Furthermore, this model can calculate the social effect of the FWH.


This paper presents the development of the ONROAD vehicle exhaust emission model for estimating CO and HC emissions. This model is developed based on the on-road emission data collected from five highway locations in Houston area using a remote emission sensor; The ONROAD emission estimation model establishes relationships between the on-road vehicle exhaust emission rates and a vehicle's instantaneous speed profile. Since a vehicle's instantaneous speed profile is a function of different traffic demand and control scenarios, this emission model can be used to estimate the emission implications of alternative traffic control and management strategies. Because of the aggregate nature of the ONROAD emission model, it can be easily incorporated into a traffic simulation or dynamic traffic assignment model where a vehicle's instantaneous speed profile can be tracked consistently. Hence, this emission model is ideal for traffic simulation and optimization analyses.

AB This paper examines four minimum path tree building and weight selection strategies that will likely affect the accuracy and computing time of a discrete dynamic traffic assignment process. These four strategies represent a combination of two different tree-building strategies and two different tree weight selection strategies. Slice-by-slice tree building and step-by-step tree building are the two tree building strategies that can be used, and successive average and tedious search are the two methods that are considered for the tree weight selection. It is found that the slice-by-slice tree building can save considerable computing time when combined with successive average weight selection and considerable computer memory when combined with the weight search method with a relatively reasonable dynamic assignment outcome. The step-by-step tree building combined with successive average weight selection produces the most accurate assignment result.


AB A new approach to solving the dynamic traffic assignment problem is presented. DYNAMIC is a traffic simulation model that performs a macroscopic network equilibrium analysis, similar to most traditional transportation planning oriented network equilibrium methods, but is responsive to operational network dynamics in a fashion that has traditionally only been observed in traffic engineering oriented simulation models.


AB The paper proposes a conjecture on the equivalence between a day-to-day stationary link flow pattern and traffic network equilibrium. Without imposing any condition on the link travel cost functions, we prove the conjecture in both static and dynamic transportation networks, under three different cost-responsive route choice mechanisms. This equivalence suggests that the monitoring and analysis of traffic patterns can be conducted on the level of the links rather than paths with implications for intelligent transportation systems.


AB In this paper, we present a unified treatment and analysis of a dynamic traffic network model with elastic demands formulated and studied as a projected dynamical system. We propose a travel route choice adjustment process that satisfies the projected dynamical system. Under certain conditions, stability and asymptotical stability of the equilibrium patterns are then derived. Finally, two discrete-time algorithms, the Euler method and the Heun method, are proposed for the computation of the solutions, and convergence results established. The convergence results depend crucially on stability analysis. The performance of the algorithms is then illustrated on several transportation networks.

The assignment problem of the multiple origin-destination stochastic system optimal dynamical traffic network flow is considered. The optimal model of problem is set up. The model is simplified by the way of mathematics analysis. Under the condition of the optimal flow, the special properties of the simplified model of the link of the dynamical traffic network now of stochastic system are analyzed by using the Lagrangian condition and the batch scheduling theory presented by Xianwei Zhou. Finally, the batch parallel routing algorithm with polynomial time is designed by using the batch scheduling and the model's special properties.


This paper is concerned with the existence of solutions to a dynamic network equilibrium problem modeled as an infinite dimensional variational inequality. Our results are based on properties of operators that map path flow departure rates to consistent time-dependent path flows and other link performance functions. The existence result requires the introduction of a novel concept that strengthens the familiar concept of First-In-First-Out (FIFO).

Ziliaskopoulos, AK, Waller, ST (2001) An Internet-based geographic information system that integrates data, models and users for transportation applications. Transportation Research 8C, 427-444

This paper is concerned with the development of an Internet-based geographic information system (GIS) that brings together spatio-temporal data, models and users in a single efficient framework to be used for a wide range of transportation applications - planning, engineering and operational. The functional requirements of the system are outlined taking into consideration the various enabling technologies, such as Internet tools, large-scale databases and distributed computing systems. Implementation issues as well as the necessary models needed to support the system are briefly discussed.


Recently, Daganzo introduced the cell transmission model-a simple approach for modeling highway traffic flow consistent with the hydrodynamic model. In this paper, we use the cell transmission model to formulate the single destination System Optimum Dynamic Traffic Assignment (SO DTA) problem as a Linear Program (LP). We demonstrate that the model can obtain insights into the DTA problem, and we address various related issues, such as the concept of marginal travel time in a dynamic network and system optimum necessary and sufficient conditions. The model is limited to one destination and, although it can account for traffic realities as they are captured by the cell transmission model, it is not presented as an operational model for actual applications. The main, objective of the paper is to demonstrate that the DTA problem can be modeled as an LP, which allows the vast existing literature on LP to be used to better understand and compute DTA. A numerical example illustrates the simplicity and applicability, of the proposed approach.