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Editorial: Day-to-Day Dynamics in Transportation Networks

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The traditional equilibrium approach for traffic assignment and transportation planning provides a description of a self-consistent state of the transportation network, which it is assumed would arise if network characteristics (such as roadway capacity, link performance functions) and travel demand were to remain unchanged for an extended period of time, and if travellers had full and complete information. Clearly this involves strong assumptions; for example, an equilibrium state of the transportation network may never be realized in the reality of varying network link capacity and varying demand over the planning horizon. Therefore, the traditional equilibrium analysis is only a crude approximation of what the future system may be. Nevertheless, equilibrium analysis has its appeal – it is relatively simple and can be described by a set of well-defined mathematical expressions.

In contrast, the new generation of dynamic network models considers the network evolution from day to day, or from period to period, as travellers learn from their past experiences as the network and demand vary. This is a much richer framework to describe and model dynamic networks in the presence of disruptions, as networks are subject to link failures from time to time, a phenomenon which is becoming increasingly common due to ageing infrastructure. Moreover, many contend that understanding the process or trajectory toward equilibrium is just as important, as it involves understanding the learning process and behavioural adaptations, and such an understanding is instrumental for transportation management. It suffices to say that many aspects simply cannot be answered by traditional equilibrium analysis. In addition, what is more prevalent and important is the emergence of various sources of information-sharing via social networks, which drastically change how travellers plan and decide on their trips. Such changes have important consequences on how transportation management ought to be conceived and implemented. The new generation of dynamic network models promises to be much more

flexible and capable of incorporating network disruptions as well as various forms of information sharing, unsteady conditions, and learning processes among travellers.

In fact, the dynamical system approach to modelling transportation networks can be traced back to as early as the mid-1980's, but it was not until recently, the late 1990's and 2000's, that this approach started to gain momentum, as is evident from the increasing number of publications on this approach. We believe that it is now an opportune time to review what has been accomplished in the last 20 years or so, and to look ahead what promises this approach holds, and what research questions, if answered, will significantly move this approach forward. This objective motivated the Croucher Foundation Advanced Study Institute on "Toward a New Generation of Dynamic Network Models" held on November 18-20, 2014, in Hong Kong, and special sessions at the 5th International Symposium of Dynamic Traffic Assignment held on June 17-19, 2014, in Salerno, Italy, where experts from around the world presented papers on the day-to-day dynamical system approach for modelling transportation networks. These events subsequently led to the organization of this special issue on "Day-to-Day Dynamics in Transportation Networks" here.

The main objective of this special issue is to look beyond the traditional equilibrium analysis and explore a new approach toward modelling transportation networks, which we hope will open up theoretically interesting, yet practically important directions for modelling and managing dynamic transportation networks. Specifically, seven papers are collected in this special issue, summarized below:

The first paper, "A general stochastic process for day-to-day dynamic traffic assignment: formulation, asymptotic behaviour, and stability analysis" by Cantarella and Watling, presents a general modelling approach for modelling day-to-day dynamic assignment through discrete-time stochastic and deterministic process models, including an explicit modelling of users' habit as a part of route choice behaviour. Results of such analyses are used for deriving conditions to assure that the mean process is dissipative, i.e. it converges to some kind of attractor.

The second paper, "Statistical methods for comparison of day-to-day traffic models" by Hazelton and Parry, contends that the efficacy of day-to-day dynamic traffic models for transport planning and the study of traveller behaviour depends on appropriate model selection. In incorporating sophisticated representations of traveller learning, it is important to ask whether the available data can support such an effort. This paper investigates the extent to which it is possible to learn about day-to-day traveller behaviour from observations on traffic counts collected over a sequence of days.

The third paper, "Sensitivity analysis based approximation models for day-to-day link flow evolution process" by Wang, He, and Peeta, proposes three approximation models for the day-to-day traffic flow evolution process based on the sensitivity analysis of the network loading sub-problem in a link-based day-to-day model: first-order approximation, second-order approximation, and variable reduced approximation. The applicability conditions of these proposed approximation models are derived, and demonstrated with a numerical example.

The fourth paper, “Day-to-day departure time modeling under social network influence” by Xiao and Lo, investigates the influence of information shared on social media on commuters’ day-to-day departure time choices. The study introduces a general framework which can be applied to any social network structure, with the learning process modelled with Bayesian learning theory. The properties of this learning model and the dynamics of the day-to-day departure time choice are analysed, and the parameters of the learning model estimated based on an experimental data set.

The fifth paper, “Advanced traveller information systems under recurrent traffic conditions: network equilibrium and stability” by Bifulco, Cantarella, Simonelli, Velonà, analyses the stability of traffic equilibrium, with advanced traveller information systems (ATIS) explicitly modelled. The paper discusses the role played by information in the day-to-day dynamics of the traffic network and in system stability at equilibrium. The paper further examines changes in the fixed point(s) in the absence of ATIS, how the theoretical conditions for fixed-point existence and uniqueness are affected, and the impact on the stability properties and the stability region at equilibrium.

The sixth paper, “Day-to-day dynamical model incorporating an explicit description of individuals’ information collection behaviour” by Iryo, proposes a continuous and deterministic day-to-day dynamical model that explicitly incorporates microscopic user behaviour about information collection. The paper then derives the underlying macroscopic model, and studies its properties in terms of convergence towards a user equilibrium solution. The paper then illustrates the properties via a numerical study.

The seventh paper, “Dynamic pricing in discrete time stochastic day-to-day route choice models” by Rambha and Boyles, develops probabilistic route choice models to determine when and how travellers switch paths. This approach results in stochastic processes with steady state distributions containing multiple states. This paper then proposes an average cost Markov decision process model to reduce the expected total system travel time of the logit route choice model using dynamic pricing. A simple example to illustrate the application of the approach is also presented.

The seven papers published in this special issue illustrate the wide scope of studies conducted to achieve a better understanding of the foundation and extensions of the day-do-day dynamical approach for modelling transportation system performance. We hope that this special issue will inspire and stimulate new research initiatives and efforts in this actively evolving field.