Transportation Science

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

TSS Dissertation Abstracts—Abstracts for the 1996 Transportation Science Section Dissertation Prize Competition

Patrick Jaillet,

To cite this article:
Patrick Jaillet, (1997) TSS Dissertation Abstracts—Abstracts for the 1996 Transportation Science Section Dissertation Prize Competition. Transportation Science 31(1):83-94. https://doi.org/10.1287/trsc.31.1.83

TSS Dissertation Abstracts

Abstracts for the 1996 Transportation Science Section Dissertation Prize Competition

PATRICK JAILLET

Chair, 1996 TSS Dissertation Prize Competition

The *TSS Dissertation Prize Competition* is the oldest and most prestigious competition for doctoral dissertations in the transportation science area. On behalf of the TSS dissertation prize committee, I am pleased to provide this report on the 1996 competition.

Eligible doctoral dissertations were those completed and submitted between June 1, 1995 and May 31, 1996 in the area of transportation science. To be considered, a dissertation had to be nominated by the thesis supervisor and accompanied by a nomination letter. This year, a record number of 25 dissertations were submitted for consideration by the judging committee. The committee was chaired by Professor Patrick Jaillet, The University of Texas at Austin, and consisted of:

- Professor Siamak Ardekani, The University of Texas at Dallas
- Professor Michel Gendreau, University of Montreal
- Professor Randolph Hall, University of Southern California
- Professor Garrett van Ryzin, Columbia University

I would like to extend my sincere thanks to the judges for the time and effort they devoted to the difficult task of judging these entries. In addition to the record-breaking number of submissions, the quality of the theses were outstanding (an understatement) and the choices were difficult. Overall this is a clear and powerful indication of the amazing current vitality of the field of Transportation Science.

The awards were announced at the Fall meeting of INFORMS in Atlanta. The first prize winner was DR. TASSIO CARVALHO of Princeton University for his thesis "Dynamic Control of Spatial Resource Allocation Problems."

Honorable mentions went to DR. CHRISTOPHER CAPLICE of the Massachusetts Institute of Technology, DR. KERRY MALONE of the Massachusetts Institute of Technology, and DR. ERIK VERHOEF of the University of Amsterdam.

It is important to remember that the submissions to the TSS Dissertation competition are already distinguished by the fact that they have been nominated for the award. Each makes a unique and valuable contribution to transportation science, and all entrants and their advisors deserve warmest congratulations. Abstracts for the 25 dissertations are provided below, winners first and then in alphabetical order by author.

First Prize
Dynamic Control of Spatial Resource Allocation Problems

TASSIO CARVALHO

Even with extensive simplification in the modeling process, standard formulations for dynamic fleet management may result in very large linear programs. These models have restricted application in practice for two reasons. The first one is that side constraints that exist in practice, such as those

Transportation Science
Vol. 31, No. 1, February 1997

0041-1655/97/3101-0083 $05.00

needed for time windows, cannot be easily handled. The second one is that they are computationally difficult to solve due to degeneracy and lack of integrality of the optimal solution.

In this thesis we propose a new solution approach for dynamic fleet management that circumvents these two problems. Instead of using a large-scale linear program that optimizes over space and time, we have formulated the problem as a dynamic program, and developed an approximation technique that is extremely easy to solve. The resulting solution procedure is much closer to a special type of optimal control problem, and provides a tremendous level of flexibility that is not achievable using more classical large-scale optimization methods. Also this new formulation provides solutions which are always integer, and is fast enough to be used in a real-time environment.

The formulation results in a procedure where a set of simple problems that result from the decomposition are solved iteratively. The solution of the simple problems is guided by the presence of two types of control variables that capture network information. One type of control is a limit on how many empty vehicles can move between each pair of terminals at each time period. The other type of control is a measure of the desirability of having more vehicles at each terminal at each time period. Because the technique can be viewed as controlling a network of queues of reusable resources (vehicles), we refer to the formulation as a *Logistics Queuing Network*.

Using the assumption that the fleet of vehicles is homogeneous, the basic principles of the Logistics Queuing Network approach are first presented. The major question is how to come up with values for the variables that control the solution of these problems. We provide two methods: a gradient approximation method, and a multiplier adjustment method. Extensive numerical work shows that this approach produces solutions that are within two percent of the global (noninteger) optimum, with run times that may be 10 to 100 faster. We then proceed to problems where the fleet is composed of several types of vehicles and partial substitution is allowed. Again we perform extensive numerical work showing that this formulation can handle problems that are too large for commercial linear solvers. Finally, we extend the formulation to allow for a vehicle handling more than one shipment at the same time (consolidation) and employ it in the context of intermodal transportation.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Civil Engineering and Operations Research at Princeton University. The thesis supervisor was Warren Powell.

Honorable Mention

An Optimization Based Bidding Process: A New Framework for Shipper–Carrier Relationships

CHRISTOPHER CAPLICE

This thesis addresses how shippers (buyers) should procure transportation services from truckload (TL) motor carriers (suppliers). TL carriers operate over irregular routes moving directly from origin to destination without any intermediate stops for load consolidation.

The majority of the costs for direct modes can be divided into two activities: line-haul movement and connection to a follow-on load. Line-haul movement costs are mainly variable with distance (fuel, tires, wages) and are fairly stable. The costs associated with connecting to follow-on loads consist of deadheading (movement of an empty truck from its current position to the location of a new load) and dwell time (time the driver has to stay at a location waiting for a follow-on load to be identified). The cost of making a connection is never known with certainty by a carrier due to short dispatching lead times and the overall spatial and temporal variability of shipper demand. The uncertainty in making a connection leads to price hedging and can be a major element of a TL carrier's costs. This uncertainty in connection costs also creates lane interdependencies, that is, the cost of serving one lane (an origin–destination pair) is affected by the other lanes that that carrier is serving. Thus, TL carriers exhibit economies of scope.

While generic procurement strategies focus on helping suppliers achieve economies of scale, greater benefits for transportation services can be derived by focusing on economies of density and scope. The thesis argues that shippers should follow different strategies for procuring direct (TL) and consolidated transportation services. For TL, the shipper should provide carriers with opportunities to select and bundle lanes together in order to reduce connection costs and, thus, achieve economies of scope.

This thesis makes four contributions: First, the effect of economies of scope on shipper–carrier relationships are analyzed and a network-based justification for the use of contracting in the seemingly perfectly competitive market for TL trucking is made. Second, a decision framework for designing

TL carrier bids is developed, to include the use of combinatorial auctions. Conditional bids are introduced as a method of reducing carrier hedging due to connection uncertainty. Third, a methodology for identifying potential efficient aggregations of lanes is developed and applied to an actual shipper's network. Finally, optimization models incorporating conditional bids and system restrictions are developed and used to assign carriers to lanes in a shipper's network. These models are applied to data from an actual TL bid.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Civil and Environmental Engineering at the Massachusetts Institute of Technology. The thesis supervisor was Yossef Sheffi.

Honorable Mention

Dynamic Queueing Systems: Behavior and Approximations for Individual Queues and for Networks

KERRY MALONE

In this thesis, we develop and analyze methods for approximate analysis of networks of single-server dynamic queues. Our focus on these networks of queues was motivated by the national network of airports. The use by the airlines of "hub-and-spoke" network configurations that create a tight "coupling" among flights at geographically dispersed airports causes delays at one major airport to propagate rapidly throughout the system. The research presented in this thesis provides, among other results, evidence that the assumptions of a decomposition approach for modeling a network of queues may be appropriate in the context of a network of airports. More specifically, we investigate three facets of these queueing problems.

First, we develop and test new approximate methods for analyzing individual queues with time-varying Poisson arrival processes and Erlang, hyperexponential and general non-phase-type service-time distributions. These new methods are simple to implement, efficient, and have limited computer memory requirements. In cases in which exact results can be found, the exact methods require 3–400 times as much CPU time as the approximations. Our computational tests cover cases of moderate to heavy utilization. We show that under many system conditions, these methods give estimates within 5% of exact system measures.

Second, we propose and test an approximate decomposition method for analyzing open networks of single-server dynamic queues. This method allows analysis of systems for which exact methods of analysis do not exist, or are infeasible to implement due to time or computer memory constraints. It uses an individual queue approximation method to estimate delays at queues, and a propagation algorithm to model the interactions among the queues. The decomposition approach is computationally and computer-memory efficient. Our results indicate that the exact solution requires two to three orders of magnitude more CPU time than the decomposition method, and the decomposition method can give estimates within 5% of exact system measures.

Third, we investigate aspects of the behavior of queueing systems with time-varying arrival and service rates. We examine the time lag between a peak in system utilization and corresponding peaks in the mean and variance for the number of customers in an $M(t)/M(t)/1$ system. We establish a necessary condition for the times at which local extremes in the mean will be achieved. In cases in which system utilization exceeds one during some period, we show that the local peak in the mean induced by this period of oversaturation occurs strictly after the end of the oversaturation period.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Operations Research at the Massachusetts Institute of Technology. The thesis supervisor was Amedeo Odoni.

Honorable Mention

Economic Efficiency and Social Feasibility in the Regulation of Road Transport Externalities

ERIK VERHOEF

The regulation of road transport externalities (environmental pollution, noise annoyance, accidents, and congestion) has come to the forefront as one of the most important issues in contemporary transport policies. A *laissez-faire* approach to these problems is not viable. More stringent regulation of these externalities seems both desirable and necessary; however, the design of such policies is often not straightforward and may therefore be the subject of heated debate. In this dissertation, the regulation of road transport externalities is studied from the economic perspective, taking explicit account of complexities in regulation that are relevant for road transport. Both efficiency aspects and aspects of eq-

uity and social feasibility of regulation that are too often ignored are addressed.

In the first part of the dissertation, we primarily consider allocative efficiency of regulation. We first show that the standard Pigouvian solution of marginal external cost pricing is usually not sufficient to achieve optimality in externalities generated by road transport. We then consider second-best alternatives to the first-best Pigouvian benchmark policy, which do not allow to fully capture the heterogeneity that is likely to exist among road users. The optimal second-best fees are derived and discussed for simple situations such as parking fees, fuel taxes, peak hour permits, and area licenses. We also consider the effect of network environment in which regulation on a part of the network spills over on an unregulated part. The regulators has to trade off a number of "subgoals." As a result the second-best fee may actually turn out to be a subsidy. We then study the relative efficiency of, and interaction between, various information and pricing instruments for the regulation of stochastic congestion, such as in an advanced travelers' information system. It is found that information provision and "flat" tolling, based on expected rather than actual congestion, are highly complementary: the combination of these two instruments performs almost as good as the theoretical first-best solution of "fine" tolling, based on actual congestion. We then explore the spatial dimension of transport via a spatial price equilibrium model.

In the second part of the dissertation, we study the distributional aspects and social feasibility of the regulation of road transport externalities. We first consider the welfare effects and analyze the equity aspects between generators and receptors of external costs. We finally study the discrepancy between economic theory and practice of regulating road transport externalities from the viewpoint of the trade-off between efficiency, effectiveness, and social feasibility.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Economics at the Free University Amsterdam. The thesis supervisor was Piet Rietweld.

The Values of Waiting Time and a Seat on the Bus: Some Evidence from Singapore

GARY BARNES

Mohring, Schroeter, and Wiboonchutikula (1987) provided estimates of the values that bus passengers place on the time spent waiting for bus service and on the comfort level of the bus. This dissertation extends theirs by using methods that make it possible to use data that was omitted from the original analysis, and that improve the quality of unobserved variable estimates. These improvements help to clarify some anomalous and conflicting results from the original study.

Waiting time and comfort values can be inferred from the choices that passengers make among competing services that differ in these two characteristics. The unusual size and richness of the data set used here makes it possible to identify the importance of these factors with a high degree of precision.

There are two important findings. The first is that the value of waiting time, expressed as a percentage of the wage rate, rises linearly with income, from 28% of the wage rate at the 10th percentile of the income distribution, to 65% at the mean, to 180% at the 90th percentile of the income distribution. Second, the value of a comfortable bus ride is quite low, and this values does not increase with the length of the ride.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Economics at the University of Minnesota. The thesis supervisor was Herb Mohring.

Mathematical Models for Transportation Demand Analysis

MICHEL BIERLAIRE

Understanding transportation demand is difficult, mainly for two reasons. First, traveling is not an end in itself. Indeed, people travel in order to carry out activities or to fulfill some needs. Second, the complex nature of human behavior introduces uncertainty, unpredictability, and randomness in the choice process.

This thesis considers two important aspects of demand modeling: Origin–Destination (O–D) models, and choice models. Both are designed to reproduce observed data as well as possible, but they differ in their underlying assumptions and structures. Origin–Destination models represent transportation demand through trip matrices, containing, for each O–D pair, the number of individuals making this particular trip. Choice-oriented models consider transportation demand as a sequence of choices operated by the travelers: activity choice, destination choice, transportation mode choice, etc. For O–D models, we consider generalized least-

squares algorithms and present efficient algorithms to solve large scale such problems, as well as a new O–D matrix estimation method that can take into account detailed information about the structure of some columns of the matrix. For the choice models, we focus on the logit model, and on its generalization, the *hierarchical logit model*. We describe a robust and powerful algorithm for the full-information estimation of nested logit model, and develop a theoretical justification concerning the specification of the so-called alternative specific constants.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Mathematics at the University Notre-Dame de la Paix de Namur. The thesis supervisor was Philippe Toint.

Static Passenger Assignment in Congested Transit Networks: A Model and a Solution Algorithm

BELGACEM BOUZAIENE-AYARI

In this thesis we formulate a new model to assign passengers to dense congested transit networks with overlapping lines in order to estimate the associated network performance measures. The following basic assumptions, which are reasonable in the context of large scale networks, have been considered. We suppose that the origin–destination travel demands are constant over time, that there is no synchronization between the lines serving the network, and that passengers arrive randomly at transit stops and respect the *first-in first-out* discipline. The well-known idea which states that passengers use *strategies or hyperpaths* rather than single routes to get to their destinations applies in such a context.

In the first part of the thesis, we deal with the bus stop problem and we propose a general stop model based on the hyperpaths concept. Two special cases "the new stop model with explicit capacity constraints" and the "hyperbolic stop model" are shown to provide better results than previously described hyperpath stop models.

In the second part we propose a new model for the static passenger assignment in congested networks where the passenger behavior at bus stops is described by the general model proposed above. We provide the existence and uniqueness conditions for the associated equilibrium-fixed point models, and numerical results on a small network.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Computer Science and Operations Research at the University of Montreal. The thesis supervisors were Michel Gendreau and Sang Nguyen.

Probabilistic Analysis and Practical Algorithms for Multi-Echelon Distribution Models with Bin-Packing Features

ANN CHAN

The impact of integrated inventory and routing strategies was recently emphasized by Stalk et al. (1992) while studying Wal-Mart developing into the largest and highest profit retailer in the world. This success story was attributed by Stalk et al. to a focus on satisfying retailer needs by efficient logistical design and planning. "The key to achieving these goals was to make the way the company replenished inventory the centerpiece of its competitive strategy." Stalk et al. identify a number of major components in this strategic vision, most importantly, a logistics technique referred to as cross-docking. This refers to a distribution strategy in which the stores are supplied by central warehouses which act as coordinators of the supply process, and as transshipment points for incoming orders from outside vendors, but which do not keep stock themselves. This distribution strategy possesses an important challenge theoretically: why does it perform so well in practice?

To answer this question, we consider the problem of integrating inventory control and vehicle routing into a cost-effective strategy for some distribution systems. Building on the so-called zero-inventory policy (replenish when the inventory is empty), we construct very effective inventory control and vehicle routing strategies. The analysis characterizes the asymptotic long run average cost of the best strategy, which is related to the bin-packing problem.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Industrial Engineering and Operations Research at Columbia University. The thesis supervisor was David Simchi-Levi.

Service Considerations and the Design of Strategic Distribution Systems

MICHAEL COLE

The research develops a distribution network design model, Strategic Inventory Location Allocation

System (SILAS), that considers customer service and is both comprehensive and solvable. Unlike traditional hierarchical design approaches, SILAS considers customer service issues simultaneously with such issues as warehouse location, customer allocation, and channel selection.

The SILAS design problem is defined as follows: given a set of plants and customers and the potential components of a distribution network, design a network of warehouses, transportation links, and inventories such that customer demands and service requirements are met at the lowest total cost. The outputs of the SILAS model include total system cost, number and location of plants and warehouses, allocations of customers to warehouses and warehouses to plants, plant production levels, frequency and size of inventory replenishments, safety stock levels, and actual service levels provided by each warehouse.

Overall, the model is a capacitated fixed-charge multicommodity network flow model with nonlinear service constraints. The nonlinear constraints are linearized to transform the model into a mixed integer program. The linearizations provide a reasonable trade-off between accuracy and solvability. The final linear model is tested for a number of cases, and is shown to be solvable for reasonably sized problems.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Industrial Engineering at Georgia Institute of Technology. The thesis supervisor was Marc Goetschalckx.

The Values of Flexibility in Public Cost-Benefit Analysis. Investment and Choice in Technical Systems for Public Transit

LAURENT DENANT-BOEMONT

In this dissertation we show how to extend the field of Cost–Benefit Analysis through the integration of flexibility in dynamic choice assessment, and thus increase the likelihood of its use in helping decision-making in the public sector.

The question of flexibility versus irreversibility becomes more and more central for transport policy decision-makers. There is a large diversity of technical issues for new links of urban mass transit, for railway improvements, for new airport terminals, or for any multimodal policy. In general, both decision-making theory and cost–benefit analysis fail to integrate the dynamic aspects of the relationship between risk and restriction for the future choices.

The goal of this dissertation is to show how cost–benefit analysis could be adapted through the integration of flexibility in dynamic choice assessment. In the first part of the dissertation, the logical relationships between cost–benefit analysis and theoretical development in economics such as welfare economics and statistical decision-making theory are outlined. In the second part, we then show how to take into account the dynamic aspects mentioned above, and how to consider a genuine assessment of the choice flexibility, static versus dynamic.

This thesis was submitted in partial fulfillment of the requirements for the degree of Docteur in the Laboratoire d'Economie des Transports, CNRS Lyon. The thesis supervisor was Alain Bonnafous.

Constructing Monthly Work Schedules in the Airline Industry

MICHEL GAMACHE

Airline industry must deal each month with two types of crew scheduling problems which are currently solved sequentially: the well-known Crew Pairing Problem followed by the Monthly Crew Assignment Problem. This thesis concentrates on the latter. The goal is to construct monthly schedules for crew members by assigning pairings, days off, annual leaves, training periods, etc. There are different ways to construct schedules: bidline, rostering, and preferential bidding. In a *Bidline Problem*, anonymous schedules are first constructed and then chosen by the employees according to their seniority. In a *Rostering Problem*, a personalized schedule is constructed for each employee. In a *Preferential Bidding Problem*, personalized schedules are constructed as before, but also considering a set of employees' weighted bids which reflect their preferences.

The thesis presents the first optimal algorithms for solving the Rostering Problems and Preferential Bidding Problems, the two most difficult to solve among the three approaches. The problems are modeled as generalized set partitioning problems and solved by intricate uses of branch-and-bound algorithms, column generation techniques, and powerful new cuts. Excellent results both in solution time and quality have been achieved in very large problems, and the resulting software for the Preferential Bid-

ding Problem is now in use in many commercial airlines.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Mathematics at the Ecole Polytechnique de Montréal. The thesis supervisor was François Soumis.

Polyhedral Combinatorics: Routing–Location Problems

JUAN JOSE SALAZAR GONZALES

The thesis is on the analysis of the polyhedral structure and on the design and evaluation of exact and heuristics algorithms for the Cycle Problem (of finding a simple cycle of minimum total length), the Generalized Traveling Salesman Problem, the Orienteering Problem (of finding a route for a vehicle not exceeding a total given time and maximizing total "reward," each city to be visited having an associated reward), the Symmetric Capacitated Vehicle Routing Problem, the Cell Suppression Problem (a type of routing–location problem with application on the protection of sensitive data in a statistical two-dimensional table), and the Generalized Uncapacitated Facility Location Problem. All these problems are of fundamental importance in the area of production and distribution of goods. Real-life applications of the considered problems are also described.

For each of these NP-hard problems, original formulations, polyhedral analysis, efficient separation procedures, and effective exact and heuristic algorithms are presented. All the proposed algorithms have been extensively tested on both randomly generated and real-life instances, and clearly outperform previous approaches proposed in the literature.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Computer Science at the Universidad de la Laguna. The thesis supervisors were Paolo Toth and Matteo Fischetti.

Freight Terminal Layout and Operations

KEVIN GUE

We develop economic models of freight terminals for the less-than-truckload motor carrier industry. Our models capture important detailed aspects of terminal operations, such as worker travel time, waiting time due to congestion, multiple material handling systems, and information about incoming freight flows.

We use our models to improve the layout of the terminal; that is, how incoming and outgoing trailers are assigned to doors on the dock. Our layouts reduce labor costs by achieving the right balance between travel distances and congestion. We validate our models with data from three large less-than-truckload carriers and describe the implementation of a layout at one of these carriers.

We also use our models to estimate the value of information about the content of incoming trailers. Knowing the contents of incoming trailers allows planners to schedule those trailers into the right doors on the dock. We show how to change the layout to exploit freight flow patterns that result from scheduling policies based on different levels of information.

Our results suggest that freight terminals in less-than-truckload can reduce labor cost by 2–5% by improving layouts, and by an additional 3% by using a simple scheduling policy for incoming trailers. Finally terminals can reduce labor costs by 15% by incorporating detailed freight information into the layout and changing the layout more frequently.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Industrial and Systems Engineering at Georgia Institute of Technology. The thesis supervisor was John Bartholdi.

A Decentralized Architecture and Local Search Procedures for Real-Time Route Guidance in Congested Vehicular Traffics Networks

YASER HAWAS

The principal focus of this dissertation is on the route guidance problem faced by a set of local controllers with partial or limited information on time-dependent O–D trip desires as well as current network conditions. Two specific architectures are addressed: a non-cooperative decentralized architecture where controllers work independently and possess no perfect knowledge regarding the network conditions, and a cooperative architecture with individual controllers exchanging information to enrich the knowledge level and enhance the heuristics.

These architectures offer the capability to operate under various knowledge levels (limited to full-knowledge) regarding the flow pattern. A family of local rules are developed for the non-cooperative and cooperative structures. Optimal control formulation is developed to assess the quality of the rule-based architecture relative to a centralized benchmark architecture.

A simulation-assignment modeling framework is developed to assess the efficiency and robustness properties of the distributed control systems. A number of simulation-based experiments are performed to test alternative local structure, rules, and heuristics, and to gain insights on several aspects of the problem by addressing the effect of the knowledge level and the quality of the heuristics.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Civil Engineering at The University of Texas at Austin. The thesis supervisor was Hani Mahmassani.

Perception Updating and Day-to-Day Travel Choice Dynamics: Models and Computational Issues

MITHILESH JHA

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 and their previous experience. The availability and perceived quality of traffic information are explicitly modeled within the proposed framework. The development of the framework is motivated by the need to predict travelers' response to different information supply strategies. The perception updating model and the choice model are integrated with a dynamic traffic simulator (DYNASMART). A simulation framework for studying perception updating and day-to-day travel choice dynamics in presence of Advanced Traveler Information Systems is also developed.

For an efficient implementation of a detailed driver behavior model and other Dynamic Traffic Assignment models, an agent-based framework for solving Advanced Traveler Information Systems/Advanced Traffic Management Systems operations is developed. Within the overall distributed framework, two models are proposed for distributed traffic simulation. The proposed distributed models do not depend on hardware capability for speed-up and hence they are useful from the practical standpoint. Simulation experiments were carried out on the basis of the proposed framework and the results are in conformity with some of the previous studies.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Civil Engineering at Purdue University. The thesis supervisors were Kumares Sinha and Samer Madanat.

A Comparison of Freight Distribution Costs for Combination and Dedicated Carriers in the Air Express Industry

MAX KIESLING

The general purpose of this dissertation is to investigate the competitive nature of the air freight industry. The investigation focuses on three components of the industry—history, logistics, and economics.

First a historical analysis of the air freight industry is used to demonstrate how dedicated freight carriers were able to emerge and quickly dominate the air freight industry following airline deregulation.

Second, several logistic modeling techniques are used to formulate system-wide cost models of air freight transportation. More specifically, logistics cost models are developed to estimate the cost of distributing freight across an air transportation network using either hub-and-spoke routing strategies, direct-route routing strategies, or a combination of both. The models include groundside distribution operations, freight handling operations, sorting operations, and flight operations.

Third the logistics models are operationalized and used to estimate the cost per package of distributing freight across a network of eight US cities for two different operating strategies.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Civil Engineering at the University of California at Berkeley. The thesis supervisor was Mark Hansen.

Dynamic and Stochastic Models with Freight Distribution Applications

ANTON KLEYWEGT

In the first part of this research, a generic resource allocation problem in a dynamic and stochastic en-

vironment is studied. Demands arrive according to a Poisson process in time. Each demand requires an amount of resource, and has an associated reward. The resource requirements and rewards are jointly distributed according to a known probability distribution, and become known at the time of the demand's arrival. Demands can be either accepted or rejected. If a demand is accepted, the associated reward is received; if it is rejected, a penalty is incurred. The problem can be stopped at any time, at which time a terminal value is received that may depend on the amount of resource remaining. The problem is to determine an optimal policy that maximizes the expected value (rewards minus costs) accumulated. We show that the optimal policy is given by an easily computed threshold rule, and that the optimal stopping time can also be calculated efficiently.

In the second part of the dissertation, we consider a fleet of vehicles in a dynamic and stochastic environment. This problem consists of finding a policy for accepting transportation requests and for dispatching vehicles, which maximizes the expected value of operating the system. We develop a Markov decision model, characterize optimal policies, and propose a number of algorithms for computing optimal solutions.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Industrial Engineering at Purdue University. The thesis supervisor was Jason Papastravou.

Safety at Rural Three- and Four-Arm Junctions. Development and Application of Accident Prediction Models

RISTO KULMALA

The dissertation looks into the safety of road junctions with the help of accident prediction models. The most important variables were those describing the magnitude and distribution of motor vehicle volumes. Several variables describing the junction layout and road environment also explained the variation in the expected number of accidents.

A new method for determining the soundness of accident prediction models was developed during the work. The method is based on estimating the amount of systematic variation in the accident data, i.e., the variation that can be explained, and separating from it the variation due to pure randomness. Accident models explained most of the systematic variation in the number of accidents. The systematic variation, however, generally accounts for just 30% of the total variation in the number of accidents.

A method is described for obtaining a reliable estimate for the expected number of accidents at a single junction based on the accident models and the observed number of accidents in the past.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Technology at Helsinki University of Technology. The thesis supervisor was Sulevi Lyly.

Dynamic-Stochastic Vehicle Routing and Inventory Problem

RODRIGO RUBIO MAQUEO

The vehicle routing and inventory problem is concerned with the joint decision of how much inventory to keep at each retail site and how to route the deliveries to these locations. This thesis presents the analysis of two types of dynamic control for a vehicle routing and inventory problem subject to stochastic demand and travel times. The system consists of a central depot with infinite supply of a product. A single truck is used to deliver the product to geographically dispersed retailers. Demand is served from these sites in a make-to-stock fashion. The objective is to minimize the long-run average cost per unit of time.

In the first dynamic control problem, we concentrate on the inventory aspect and consider two cases: a) the truck travels along a predefined TSP tour, and the controller dynamically decides how many units to leave at each site; b) the vehicle delivers a full load to one retailer (direct shipping) and the controller decides which retailer to visit next. The second model incorporates the routing aspects of the vehicle routing and inventory problem explicitly by allowing the controller to dynamically choose between the Traveling Saleman Problem or direct shipping routing schemes.

For the fixed route models, our results fully characterize a dynamic control policy that is asymptotically optimal. The limiting diffusion control problem for the dynamic routing case is more difficult. We nevertheless solve the problem under a specific double threshold policy. In all cases, numerical results show that the heavy traffic approximation is quite accurate.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Operations Research at the Massachusetts Institute of Technology. The thesis supervisor was Larry Wein.

Trip Chains: Theoretical Development and Empirical Analysis

PAUL METAXATOS

In modeling trip-chaining behavior a number of issues arise, the most fundamental being the underlying decision process. In this dissertation we argue that single-stop trip-chaining behavior is based neither on a simultaneous nor on a sequential decision process, but on a rather in-between particular type of sequential decision making process called a relative-sequential process. Moreover, we reason that single-stop trip chains seen in this relative-sequential process comprise the building blocks of complex trip chains. Subsequently the relative-sequential process is formally characterized by employing the traditions of two modeling frameworks, the deterministic entropy-based models and the probabilistic threshold theory.

Using the mathematical programming tools of the entropy-based framework, we formulate a bilevel entropy-maximizing model of work single-stop trip chains, and show that the optimality conditions of this program correspond to modified gravity models of trip chain frequencies. The threshold theory offers an explicit behavioral interpretation of looking at activity sequencing as an relative-sequential interaction process.

The models are estimated using maximum likelihood methods and calibrated experimentally. The numerical experimentation shows that theoretical developments proposed in the dissertation are very promising. In fact the estimated trip-chain frequencies fit very well to data.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Public Policy Analysis–Urban Planning at the University of Illinois at Chicago. The thesis supervisor was Ashish Sen.

Dynamic Aircraft Reassignment

GEOFFREY MURRAY

Airline schedules have traditionally been set long in advance, and any deviations from the present schedule have been due to weather or maintenance interruptions. A static schedule of this type cannot respond to the variations in demand that inevitably occur on a daily or even weekly basis. This dissertation investigates the potential for airlines to add an element of flexibility to their schedule by dynamically reassigning different aircraft to routes. These reassignments must not violate the unique constraints an airline is faced with, such as crew, maintenance, and operational issues.

Aircraft are dynamically reassigned to routes through aircraft swaps, or substitutions between a pair of aircraft. Aircraft swaps are identified by using algorithms that search for oversold and undersold flights in the network and then suggest feasible substitutions between aircraft. Forecast day-of-departure passenger demand is the criteria for identifying these swaps. A second set of algorithms examines each potential swap for adherence to constraints such as crew and maintenance. The remaining swaps are checked for a forecast increase in profit if the swap is executed. A network flow model identifies the optimal swaps from the set of feasible, profit-improving swaps.

This research used the actual March 1995 United Airlines schedule. Results from the model include a nominal increase of 0.54% in operating profit. Approximately 5% of the daily schedule was affected by aircraft swaps.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Civil Engineering at Northwestern University. The thesis supervisor was Mark Daskin.

Dynamic Statistical Models for the Prediction of Aircraft Take-off Times

ROBERT SHUMSKY

Safe and efficient management of air traffic requires accurate predictions of aircraft trajectories. In the existing air traffic system, predictions of take-off times are a major source of forecast error. This thesis presents three primary contributions: forecasting models for predicting individual take-off ties, models of aircraft flow to predict departure congestion at major airports, and methods for balancing the frequency of forecast updates with the costs of forecast inaccuracy. The models use real-time data to update parameters and generate forecasts. They are tested with data from the existing air traffic management system as well as data ob-

tained from other sources, such as commercial air carriers.

Empirical tests using data specific to Logan Airport in Boston suggest that the take-off time forecasting models achieve small improvements in forecast accuracy over existing methods when using information currently available to the air traffic management system. If additional carrier-specific information is available, the models achieve more substantial improvements. Empirical tests also demonstrate that the departure flow models produce accurate predictions of airfield congestion over both 10-minute and 1-hour forecast horizons.

We also develop forecasting algorithms which balance prediction accuracy and the cost of each forecast update. Numerical examples demonstrate that the proposed algorithms significantly improve forecast accuracy and require less updates than existing methods.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Operations Research at the Massachusetts Institute of Technology. The thesis supervisors were Arnold Barnett and Amedeo Odoni.

Locating Flow-Intercepting Facilities on a Network with Probabilistic Customer Flows

CHEN WEI XU

Most network facility location problems assume that dedicated trips to the facility are required. In reality, dedicated trips are not common when visiting facilities such as gas stations, automatic banking machines, or advertising billboards. When locating such facilities, the objective is usually to intercept as many customers as possible.

This dissertation studies the problem of locating such facilities on a network with probabilistic customer flows. When a customer sees a facility and makes a decision whether to use it, an "interception" occurs. When customers are intercepted by the first facility encountered, the case is called "full-interception." When a portion of customers is intercepted by each facility encountered, the case is called "partial-interception." When a customer is allowed to be intercepted by more than one facility, the case is called "double-counting." Otherwise it is called "no double counting."

We study the full-interception model, the partial-interception model, the double-counting model, the location model with facility set-up costs, and a "hybrid" model where the facilities are assumed to not only intercept customer flows, but also draw neighborhood customers on a distance-coverage basis. In each case, a nonlinear integer program and its equivalent linear version are formulated, and greedy heuristics are provided and analyzed. Computational results are presented as well as (for one problem) a polyhedral analysis and a branch-and-bound algorithm.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Management at the University of Toronto. The thesis supervisors were Oded Berman and Dmitry Krass.

Projected Dynamical Systems: Stability Analysis and Computation with Applications to Transportation and Economic Systems

DING ZHANG

This dissertation studies the theory and applications of a new and nonstandard class of dynamical system, called projected dynamical systems. We focus on three subjects: (1) the proposal of dynamical models, for social and economic systems that are subject to certain constraints, (2) the establishment of the stability analysis for such models, and (3) the development of discrete time algorithms for the computation of equilibria. The applications that this thesis is devoted to, include elastic and fixed demand transportation network problems, spatial price market problems, and oligopoly problems. The theoretical foundation is laid down through rigorous mathematics.

In each application chapter, a projected dynamical system model is proposed to describe the underlying competitive system of the equilibrium problem. These models extend the static variational inequality formulations of the equilibrium problems to an additional dimension of time.

An important achievement of this thesis is the establishment of the stability theory of projected dynamical systems, which is then used to provide stability analysis for the application models.

Another contribution is the development of efficient algorithms for the computation of equilibria that can be implemented on parallel computer architectures. They are derived through time discretization of the dynamical systems.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Mechanical and Industrial Engineering at the University of Massachusetts, Amherst. The thesis supervisor was Anna Nagurney.

The Dynamic Behavior of Road Traffic Flow: Stability or Chaos?

XIAOYAN ZHANG

The objective of this thesis is to investigate the dynamic behavior of road traffic flow based on theoretical traffic models. Three traffic models are examined: the classical car-following model which describes the variations of speeds of cars and distances between the cars on a road link, the logit-based trip assignment model which describes the variations of traffic flows on road links in a road network, and the dynamic gravity trip distribution model which describes the variations of flows between O–D pairs in an O–D network.

In this thesis, the three traffic models are considered as dynamical systems. The variations of traffic characteristics are investigated in the context of nonlinear dynamics. Equilibria and oscillatory behavior are found in all three traffic models; complicated behavior including doubling and chaos is found in the gravity model. Values of parameters for different types of behavior in the models are given. Conditions for the stability of equilibria in the models are established. Chaos attractors found in the gravity model are characterized by Liapunov exponents and fractal dimension.

The research in this thesis aims at understanding and predicting traffic behavior under various conditions. Traffic systems may be monitored, based on these results, to achieve a stable equilibrium and to avoid instabilities and chaos.

This thesis was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Faculty of Technology at Middlesex University in London. The thesis supervisors were David Jarrett and Chris Wright.