INDUSTRIAL & SYSTEMS ENGINEERING
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# Exact Methods for Large Scale Logistics Optimization Problems: implications for research and application in Warehouse Operations

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## Abstract

In this collaboration with Julian Yarkony (Next Generation Robotics), Udayan Mandal (Stanford University) and Louis-Martin Rousseau (University of Montreal), we consider the problem of accelerating the convergence of column generation (CG) for the weighted set cover formulation of the capacitated vehicle routing problems with time windows (CVRPTW) or deadlines.We adapt two new techniques, Local Area (LA) routes and Graph Master (GM) to these problems. We show that these methods allow us to solve problems arising in automated warehousing operations in real-time, suggesting that in many applications, resorting to metaheuristics, however powerful, is no longer necessary. LA-routes rely on pre-computing all lowest cost elementary sub-routes, called LA-arcs, where all customers but the final customer are localized in space. LA-routes are constructed by concatenating LA-arcs where the final customer in a given LA-arc is the first customer in the subsequent LA-arc. To construct the lowest reduced cost elementary route during the pricing step of CG we apply a Decremental State Space Relaxation/time window discretization method over time, remaining demand, and customers visited; where the edges in the associated pricing graph are LA-arcs. To accelerate the convergence of CG we use an enhanced GM approach. We map each route generated during pricing to a strict total ordering of all customers, that respects the ordering of customers in the route; and somewhat preserves spatial locality. Each such strict total ordering is then mapped to a multi-graph where each node is associated with a tuple of customer, capacity remaining, and time remaining.

## Date & Time

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## Bio

Amelia Regan, Professor Emerita of Computer Science and Transportation Systems Engineering at the University of California, Irvine, is the director of the Master in Supply Chain Transportation and Logistics at the University of Washington. Her current research interests include robot routing in automated warehouses, optimal contracting for freight transportation, logistics systems optimization, machine learning tools for logistics systems, technologies enabling automated driving, pedestrian and cyclist safety and sustainable transportation systems. Her research has been supported by various sources including the National Science Foundation, the Transportation Research Board and JB Hunt Inc., and has been published in more than 175 refereed journal articles and conference proceedings. Before her career in academia, she was a software engineer and research analyst with UPS and the Association of American Railroads. She is a collaborator and advisor to Next Generation Robotics (NGR.ai), a new logistics optimization company.