IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project title: Recreational Vehicle Scheduling: Flow Routing Problems on a Time Expanded Network

Project number: IMURA0079

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Research Academy theme/s

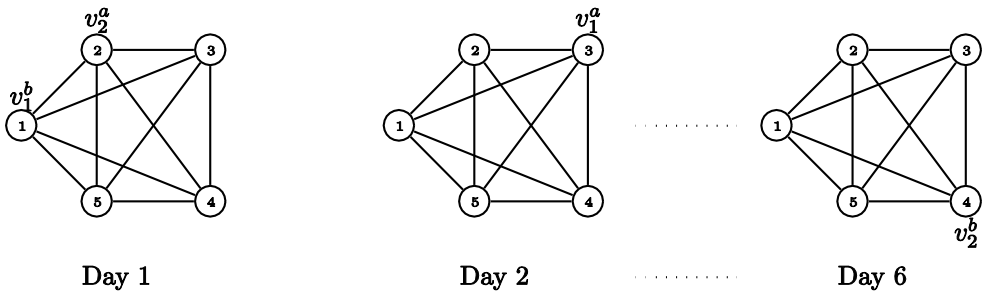
List only the research academy theme/s that is relevant to the project

1. Advanced computational engineering, simulation and manufacture

The research problem

Consider a vehicle rentals operation that is concerned with managing a fleet of different vehicles. Vehicles from the fleet are used to satisfy booking requests from customers. Booking requests are made 3-6 months ahead for specific types of vehicles for a given time period. Bookings commence at a start-depot and end at an end-depot. Many requests for bookings might only *one-way.* In other words, vehicles normally end up at a different depot to where they started. Moreover, some customers may be flexible with regard to the type of vehicle they are willing to rent (if the vehicle type that they requested is unavailable), while others may be very specific about their choice. Hence, the rental operation not only has to make sure that there are sufficient vehicles at each depot but also has to meet the requirements of the costumers. In order to do this, the operation allows vehicle substitutions (at a penalty) and also allows dead-heading from a neighbouring depot. Dead-heading is where a vehicle is driven (at a cost) from a neighbouring depot in order to satisfy a booking.

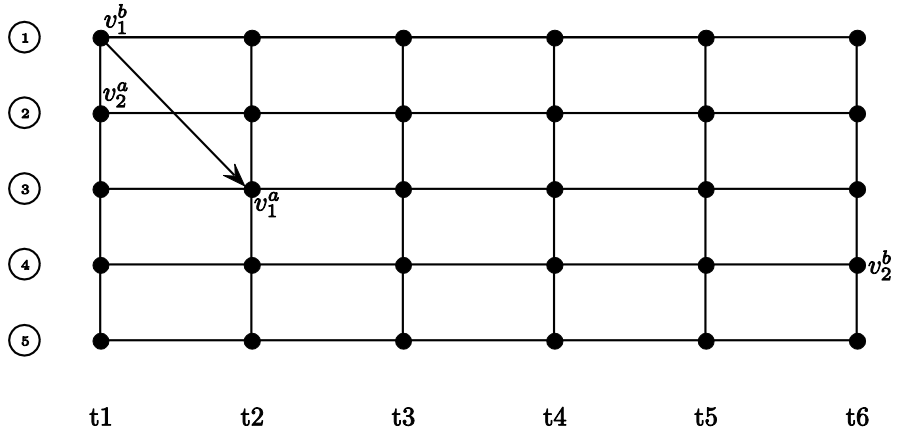
This problem can be modelled as a combination of a network flow problem (or an assignment problem) in a time-expanded network and a flow-routing problem. In the first stage, vehicles need to be assigned to bookings and a feasible path needs to be found for all resources through the network. A simplified example is illustrated in the figure below. In this example, we consider a simple booking time horizon of six days. On day-1 there is a booking at depot-1 of vehicle-1, which will become available on day-2 at depot-3. Moreover, vehicle-2 is available at depot-2, but it must be available at depot-4 on day-6.



v_i^a: availability of vehicle i

v_i^b: booking of vehicle i

Solution algorithms could be applied on a time-expanded network which consists of one copy of the node set of the given network for each time unit (we call such a copy a time layer).



It is possible to get a generic set of feasible paths in this time-expanded network by solving it as either a network flow problem or an assignment problem.

Of much greater difficulty is solving the flow routing problem on this network of “generic” optimal paths. This latter problem will form the large bulk of this research project. This problem starts with a network that consists of a set of optimal paths and allocates specific vehicles to specific paths so that in the end, all resources and all demands are satisfied.

Project aims

The aim of this project is to develop and analyze models that treat the above mentioned problems simultaneously. Thereafter other solution approaches such as heuristics or branch and bound algorithms should be developed and implemented.

Expected outcomes

This project will look at new modelling and solution approaches that minimize cost and maximize quality of service in vehicle rental networks. The outcome of this research could ideally be used as a decision support tool for vehicle rental companies.

Capabilities and Degrees Required

Linear and Network Optimization
Integer Programming
Network Flows and Network Optimization
Combinatorial Optimization