ENGSCI 263 2021: OR and Data Project Description
Truck Scheduling and Efficiency for Woolworths NZ

Woolworths NZ operates the Countdown, FreshChoice and SuperValue supermarket chains in New Zealand. Each store needs to receive goods daily to ensure their shelves are fully stocked. They operate a fleet of 30 trucks in order to move these goods from their distribution centre in Favona to their stores around Auckland.

On each day, each store receives pallets of goods from a distribution centre based on historical data on sales. Therefore, the number of pallets shipped to each store differs each day. For this model, we will work in units of pallets, and we will not differentiate between different product categories.

Each truck can carry up to 26 pallets of goods, and operates on a trip schedule that will have each truck deliver goods to a selection of stores, and return to the distribution centre. Once at the store, a pallet takes on average 7.5 minutes to unload. Current policy requires each scheduled trip take no more than four hours, on average, to complete; this includes both driving time and unloading time. Each truck costs $225 per hour to operate and can operate two (approximately) four-hour shifts per day. You may assume that the two shifts start at 8am or 2pm, and that each store only receives one delivery per day.

However, traffic conditions on Auckland roads are not always ideal, so the driving time required may well be longer or shorter depending on the time of day. This means some trucks may take more than four hours to complete their trip. In such cases, the extra time costs Woolworths $275 per hour.

On days where there are not sufficient trucks to satisfy all demand, either because of a shortage of truck time or an excess in store demand for pallets, additional trucks can be 'wet-leased' (vehicle rental that includes a driver) from Daily Freight for a cost of $2000 for every four hours of on-duty time, charged in four-hour blocks.

Woolworths NZ would like to determine a suitable truck logistics plan such that costs are minimised. They have provided you with:

- the number of pallets delivered to each store they operate over a 4 week period (pre-lockdown),
- the GPS coordinates of each store and the distribution centre,
- the road distance (in meters) and travel durations (in seconds) between each pair of stores and distribution points.

Given the current economic situation, Woolworths NZ is also considering reducing the number of stores they operate by closing a store where two stores are unusually close to each other due to historical lease agreements. They would like an estimate of the impact of closing a store in terms of their logistics planning. The savings in transport costs can be reinvested in additional trucks; each extra truck costs $5,000 in *additional* fixed costs to operate per month.

Part I

1. Analyse the data provided to develop an appropriate estimate of the number of pallets required at each store on each day which can be used in your optimisation model.
2. Using the pallet estimates, create a set of feasible trucking routes that satisfy the requirements given.
3. Formulate and solve a mixed-integer program to find the least-cost routing schedule for the truck fleet, using the demand estimates from part 1.

Part II

4. Create visualisation(s) of your proposed trucking routes, suitable for presentation to management.
5. Evaluate the quality of your schedule by creating a simulation to estimate the actual cost of satisfying actual pallet demand at every store. Your simulation should take into variations in demand and sensibly approximate the effect of traffic. Hence, give an estimate of the cost of operating your proposed routing schedule, with and without the Northern distribution centre.
6. Identify stores that could be closed under the proposal, and evaluate how the resulting cost changes affects the performance of your proposed trucking schedule. Consider also the wider implications on the systems and people that interact with the Countdown/FreshChoice/SuperValue stores and this truck logistics plan.
7. What are your recommendations to Woolworths NZ after conducting this study?

Note: this project does not have just one correct answer!

Deliverables

Group Model Report (5%)

Due Wednesday 6 October, 11:59pm.

Your group should submit a document that addresses Part I of the project description. This document should focus on your modelling and analysis of the problem and the assumptions made in formulating your model. It should be no longer than 5 × A4 sides. The document does not need to be in a formal report form (i.e. introduction / conclusions are not required). Appropriate visualisations are expected.

Like the CM project, your group should use Bitbucket to store the code developed for this project.

Lab 6 (3% total - Group Submission below is 6 /10 marks available)

Due Wednesday 13 October, 11:59pm.

In your group, produce appropriate visualisation(s) of:

- proposed trucking routes
- simulation results in terms of cost of operation or other relevant metrics.

Interpret your visualisations and make appropriate comments. Submit this as a PDF document to Canvas. These do not have to be your final results!

Individual Report (12%)

Due Monday 18 October, 11:59pm.

The individual report should cover all aspects of your model, with particular emphasis on Part II of the project description. You may appendicise parts of your Group Model Report that you refer to in the report.

The report must be in an engineering-report format suitable for presentation to management (who have a good OR / Analytics expert on their team, so some technical language can be used).

The report should be no more than 6 × A4 sides (12pt Times New Roman, or similar) from introduction to conclusions, i.e. not including front-matter (cover/title page, table of contents, executive summary etc.) and back-matter (appendices, references, bibliography etc.).

The page limit may not give you enough room for a detailed description of any models (code, worksheets, data, plots, other visualisations, etc. can go in the appendices), so you will need to present a concise description of any models and their implementation. For example, do not simply say: "Using the integer programming model from the Excel worksheet in Appendix A…", instead you should briefly outline the model in the body of the report and refer the reader to the appendix for further information. You may include sections from the Part 1 report in the appendix of this document.

In your report you need to describe your group's overall approach to solving this problem (using the pronoun "we"); however, emphasise your contribution to the project using the pronoun "I".

Although this report must be written individually, group members may share visualisations and tables.

Your BitBucket/GitHub repository must also be submitted prior to the deadline.

Contribution Summary and Reflection (0.5%)

Due Sunday 24 October, 11:59pm. Submitted as a Canvas Quiz.

As with the Computational Mechanics project, marks in the project will be reduced by up to 75% depending on the degree of non-participation.

Notes:

1. There is a lot of scope in this problem. You may need to simplify parts of the problem, which is fine, but please state in your report what assumptions/simplifications have been made.
2. Treat this as a real-world project so if there is any information that is not initially provided, you should find it from public source, request it from us (although we may not have it, or it may be too slow or expensive to obtain), or create artificial data that is (ideally) representative of real data. However, do not contact Woolworths NZ (i.e. Countdown, FreshChoice, SuperValue) about this project…