The Amazoff Company

Logistics Plan
MA424 Modeling in Operations Research

Final Project 2019-2020

Background

The Amazoff Company is a new e-commerce company that is trying to base on the UK. They heard about the LSE MA424 course, and they reach out to you looking for advice in order to setup part of the logistics plan of the company. The purpose of this project is to find a plan for the warehousing, routing and e-commerce for a period of a year.

1   Warehousing

The company is unsure about where to open the warehouses around the UK. They have information about the potential clients and their demand, but the cost of opening a facility depends heavily on the city and other factors. Your first task is to help the Amazoff Company to take a decision on where to open facilities and how to assign them to the clients. For that, generate randomly [1] 15 points in the two dimensional square $[-1, 1] \times [-1, 1]$ representing the potential locations F to open a new facility, and generate other 60 points in the same region representing the clients C. For each pair of points $(c, f) \in C \times F$, the cost of assigning a client to a given facility is given by the ℓ_1 distance between c and f. The opening cost of a facility $f \in F$ is given by $100 \cdot 3^{-\|f\|_1}$ units. Find a model to decide on the optimal way of opening and assigning facilities to clients.

Capacitated Model. Now suppose that each facility $f \in F$ has a capacity of $100 \cdot 2^{\|f\|_1}$, and suppose that each client has a demand that is uniformly distributed between zero and 25 units. Modify the above model to find the optimal way of opening and assigning facilities to clients, and at the same time respecting the facilities capacities and the clients demands.

maintain the difference?

Balanced Loads. The company would like to maintain under control the difference between the facility facing the highest demand and the one facing the lowest demand, where the demand faced by a facility is the total demand of the clients assigned to that facility. Propose a variant of the capacitated model in order to handle this. State clearly the idea behind your constraints, as well as the formulation and its correctness.

2   Vehicle Routing

Your second task is to design the routing plan for the Amazoff Company. Suppose that the company has a depot at the point $(1, 1)$ from where the vehicles start the dispatching operations. In principle suppose the company has access to a single vehicle for the dispatching operation and consider only the 25 clients with highest demand, that we call *high demand clients* in what follows. Design a model that decides on how to perform the routing operation for the single vehicle, starting on the depot and finishing there. Recall that the vehicle should deliver at every high demand client as many units as the demand. Suppose that the cost of going from client c to client $\hat{c}$ is given by the ℓ_2 distance between them.

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[1]You can generate an initial set of locations and keep them for the rest of the task, is not necessary to generate a new set every time you solve it. For example, you can generate the client and facility locations en Excel or R.

Multiple Vehicles. Suppose that now the company has access to three different vehicles to perform the dispatching operation. Design a new model to decide the routing plan for the three vehicles. Compare the total cost obtained with the one faced by having a single vehicle. As before, the three vehicles should start and finish at the depot.

Do the vehicles still depart at depot?

Multiple Vehicles and Warehousing. Suppose that now the company has access to one vehicle per facility open according to the facility location plan designed before. Taking the solution of the facility location problem as given, design a model that finds the routing of each vehicle. Recall that a vehicle of a given open facility should visit every client that was assigned to the facility in the plan found before.

fixed y[i,k]

3 Routing Special Orders

meaning visit the special orders first? make other distance much larger than the two special points?

The company deals sometimes with special orders that are to be routed with priority. Consider two new clients drawn randomly from the square $[-1, 1] \times [-1, 1]$ and suppose that the company has a vehicle that departs from the depot. Your task is to find a way of visiting each of the two new clients in the cheapest way, but it should be done in a way that the vehicle visits on the way some other clients. Suppose that the cost faced by the vehicle between two clients is given by their ℓ_1 distance, and same for the distance between the depot and any client.
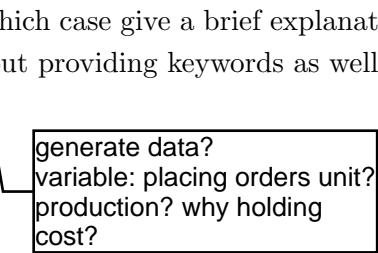
4 Internships

The company is looking for interns to be part of the analytics group, and they are implementing a new system to manage the applications. The company is offering ten internships, and every applicant should declare their preferences at the moment of applying to the internships. Namely, each applicant should provide a ranking over the positions, where to top is the most preferred one and the last is the less preferred. On the company side, they also have preferences over the applicants, depending o their skills and experience, among others. The goal is to find a matching between the internships and the applicants, covering each internship position. They heard that the MA424 students are familiar with stable matchings, and they would like to implement the assignment in this way. Your task is to help them to find such type of allocation. For that, suppose that you have 30 applicants, and each of them has a full ranking list over the internships. On the other side, suppose that the company has a full ranking over the applicants for each internship. Design a linear program to find an allocation fulfilling the above requirements. To construct the instances suppose that the ranking of each agent involved is constructed uniformly at random.

5 Uncertainty on the Demand

Objective? Maximize the profit?

The company has an analytics group that is looking for certain advice on the following situation. The demand for the upcoming months is clearly uncertain, but they have some data, which they would like to exploit. In particular, they were thinking about placing orders for a set of different products taking into account the available information. They heard that you are familiar with certain techniques on

optimization under uncertainty. Can you provide some advice on how to handle this situation? In this part you have to propose a way of dealing with this problem, only with the following information at hand: For each product you have 100 samples of the demand, and you know the unit cost at the moment of placing an order, the holding cost and the selling price. Feel free to make further assumptions, in which case give a brief explanation on how they play a role and help to improve your model. Think about providing keywords as well, or helpful references on this part.

generate data?
variable: placing orders unit?
production? why holding cost?

Deliverables and Report Contents

The Amazoff Company wants you to develop models for their problems. You can use Excel@Risk and AMPL to implement and solve these models, but you are free to use other software as well if you consider them helpful for the project, such as R, Octave, Matlab, etc. If you feel confident enough in other programming language such as Python or Julia you are also free to use them. For that you would need to get an academic license for the Gurobi/Cplex solvers. [2] It is expected that you will then analyze and discuss your findings on the basis of the questions outlined in the previous sections. You must deliver a Project Report containing your analysis and suggestions but also detailing the modeling that you have undertaken. The Project report should consist of the following (explained below in more detail):

(a) A brief **Executive Summary**, discussing your main findings. It should be completely free of any mathematical terms and discussion of modeling technicalities. It should describe the main characteristics of the solutions obtained and answer all the questions.

(b) A concise **Management Report** discussing all of your findings. The Management Report should be independent of the Executive Summary (i.e., self-contained). Ideally, the Management Report will avoid the use of unnecessary modeling technicalities.

(c) A number of **Technical Appendices**. The technical appendices will give a complete account of the modeling development. In particular, an appendix detailing the development of the optimisation models, where all entities of your models are defined and their meaning is explained in detail, together with the models clearly stated.

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[2]For information about how to get it, send an email to v.verdugo@lse.ac.uk

Guidelines

- The deadline for submitting the mock project is **17 March 2020 13:00**. One hard copy of the report should be submitted anonymously (with your exam candidate number). The electronic copy of the report, the model files and any other computer files you create should be contained in one .zip file, to be uploaded on the moodle MA424 page by the same deadline.

- You are allowed to work in groups of size **at most three** on the models and associated files.

- **All components of the report must be written individually.** This includes: the executive summary, the management report, any mathematics with associated explanation, any discussion of the relationship between the mathematics and the software used, any computer code and any description of the software features used. This is not an exhaustive list. You may not seek advice from anyone else other than your fellow MA424 students (provided you report this) and the MA424 lecturer.

- You must provide candidate exam number of all other students who you worked together with, and a brief statement on the extent of collaboration and the individual contributions. (e.g., *"we prepared the basic formulation together, and both of us had about the same contribution"*, *"we prepared the basic formulation together, but most constraints were developed by me"*, *"we worked mostly separately, but she explained to me the constraint about the maximum distance"*). Common elements of work that are not declared will be considered as cases of **plagiarism**.

- The report without the Technical Appendices should not exceed 12 pages with 11pts, single spacing. **Concise and clear reports are preferred.**

- Any project submitted without all associated computer files will be given a **mark of zero**.

- The MA424 lecturer is permitted to give you help with the implementation of your models but not the formulation.

- Recommendation: Try to ask the questions about the project during the lecturer's office hours, not by email.

Marking scheme

Modeling	30
Implementation	20
Analysis	30
Organization/Presentation	20
Total	**100**

- *Modeling.* The basic ingredients of the model are appropriately and meaningfully defined. The essential decision variables for the model are introduced with suitable types. Constraints are formulated correctly.

- *Implementation.* All scenarios and the extension are implemented in a sound manner. Data is provided in an appropriate form and separated from the model. Further, demonstrating sufficient capacity to developing "good" models: avoiding unnecessary variables and constraints, compactness of data representation as well as the use of more advanced features for defining model entities.

- *Analysis.* The report should sufficiently demonstrate the ability to recognise and report all key results of the models and relate these to the real-world problem as well as demonstrating sufficient understanding of these results with a discussion of requisite insight. Discussing limitations of the model, the possible sources of these and how they may impact on the problem decision.

- *Organization/Presentation.* A main report and technical appendices which are clear, concise, well organised, well formatted and well presented with appropriate use of figures and tables, well commented and easy to navigate files.