Aalto University

MS-E2177 SEMINAR ON CASE STUDIES IN OPERATIONS RESEARCH: INTERIM REPORT

Posti Group Oyj: Integrated cost optimization of Parcel and eCommerce supply chain

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June 6, 2020

Project status

Objectives and scope

The main objective of the project has remained the same: to develop a routing and scheduling planning tool for sorting and transporting of parcels over the planning horizon of 24 hours. This tool should give the sorting and transport schedules and also tell how to load the trucks with parcels ending in different sorting centers and terminals.

During the planning phase, we agreed with Posti to build the model under some simplifying assumptions. These included for example that all parcels are addressed equally and that trucks do not have to return to their starting locations. So far we are not going to drop these assumptions until the optimization model is fully verified. This will still take time because we received some relevant data from Posti only recently, possibly due to the Covid-19 situation which has focused Posti's work elsewhere.

Progress with respect to the project plan

Overall, the project has progressed according to the project plan. When the project plan was presented, we already had the mathematical model constructed for the most part. Thus, we were able to move on to the practical implementation rather quickly. We met once with the group to discuss how the model should be coded with Julia and JuMP. After making sure we all had the latest version of the programs, we then proceeded to develop the code in our own work times and distribute the progress with others using GitHub.

The main parts of the code were finished rather quickly since creating optimization models with Julia was familiar from university courses. When starting to solve the model with Julia, there were first some issues. Luckily, the causes for those were spotted swiftly. After that we started to solve the problem with the Cbc (Coin-or branch and cut) solver using some simple dummy data for which we were able to calculate the optimal solution by hand. As it turned out, the Cbc solver was not able to find a (near-)optimal solution in a reasonable amount of time. We then changed the solver to Gurobi, which had been suggested to us by Posti already at the start of the project. With Gurobi, a (near-)optimal solution could be found faster with the simple data, and the results with larger dummy data have also been promising. This initial model is analyzed in more detail later.

After switching to Gurobi, we developed ways to reduce the size of the model either variable or constraint wise to speed up the running times and to further examine the results of the optimization. Recently, we obtained the actual data from Posti. It seems that the data will need some preprocessing which will take time. In addition, it will require allocating resources from finalizing the implementation. In practice, this means that some (perhaps unwanted) assumptions may remain valid in the final implementation. Once the data has been processed and is ready to be used, we will proceed according to the project plan to the phases of model validation and refinement work.

Updates to the initial project plan

For the most part, the current project status is what was anticipated in the project plan. Project work will continue according to the original plan. As already mentioned, the objective and scope of the project have remained the same. Furthermore, tasks mentioned in the project plan have not changed, and we are progressing on schedule. However, the risk management plan has had some notable changes made to it.

Updates to the risk management plan

New risks that were not assessed in the project plan have arisen. Moreover, likelihoods of the risks already introduced in the project plan have changed. The updated risk management table can be found in the appendix. This section aims to motivate the updates made to the table.

Due to the Covid-19, the likelihood and severity of team member inactivity have increased. Furthermore, all the work is now done remotely which may complicate the communication between parties. At this point, the initial model has been formulated and implemented. Therefore, the risks of failing in these two tasks are not listed anymore in the table. However, if the model does not provide feasible solutions based on the data provided to us by Posti, then the model could have to be reformulated and implemented. Nonetheless, initial tests using dummy data have resulted in feasible solutions. Thus, the likelihood of implementation not providing feasible results has decreased. Testing the model has showed that the hardware affects the solving times and in some cases even the solutions. Further inconsistencies were also found. In some cases, after making simplifying changes to the model, such as removing variables or constraints, the solutions would get worse or finding solutions would take longer. The risk here is that the model is not robust.

So far the project has progressed steadily. Based on the discussions with the client, we believe that the end product will satisfy the customer requirements as long as there are no insurmountable setbacks. However, the further we have progressed, the more ideas have come up to expand the model. Our strategy is to first finish the initial simplified model and then, if there is time, we attempt to expand the model. Therefore, there is a risk that the model will not incorporate details that the customer wishes to be included in the model.

Analysis of the initial optimization model

The first tests on the model were executed with simple dummy data that consisted of a small number of parcels arriving to each of the six sorting centers at the start of the time horizon. We used uniform distributions to divide these parcels from each sorting center to all the others, and to itself, and also to distribute the parcels from the sorting centers to the last-mile terminals. For this simple case it was possible to observe the optimized

solution manually and see whether it made sense or not. An example solution is presented in Figure 1.

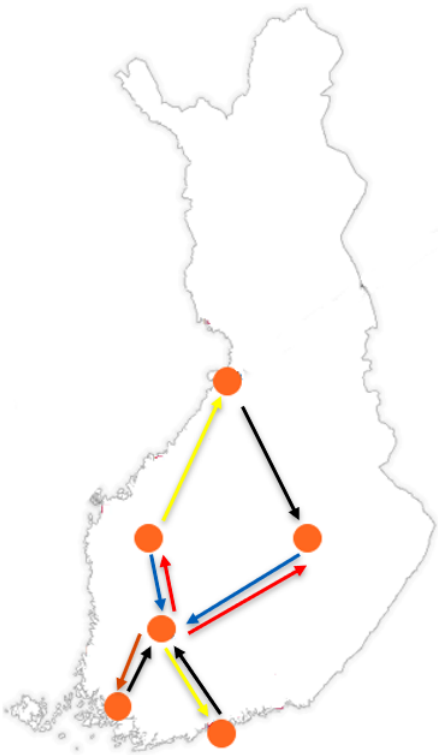

Figure 1: Example of solution obtained with Gurobi after 120 seconds. All parcels were machine sorted which was the cheapest option. The arrows represent the parcel transports between sorting centers, first the black transports, next blue, then red and last yellow. After those transports the parcels are still transported to the corresponding terminals.

At the very start of the tests, we were able to identify some issues that were simply bugs and could be fixed quickly. Then the model provided sensible results and we could also see that after running the optimization for several minutes a (near-)optimal solution could be found quite consistently, but the algorithm was not able to confirm whether it was actually the optimum or not. Because of this, we had to limit the running time of the optimization as it would otherwise run unreasonably long.

Even though these results were not perfect, we have reason to believe that the model (with its current simplifications) has been implemented correctly and, given enough time, is able to find the optimal solution to the problem. However, as we move to testing with more extensive data, validating the result becomes problematic as calculating the optimal solution quickly by alternative means becomes too difficult. Then the question becomes how do we know what is a good enough solution so that we could see how long it takes to find a solution with a low enough cost. We have already run some tests with a slightly larger number of parcels and been able to confirm at least that after a certain running

time the solution is not yet optimal. It is however also possible that given more processing power, the algorithm finishes in reasonable time.

Appendix

Risk	Likelihood	Severity	Impact	Mitigation strategies
Team member inactivity or dropout	Medium	Medium	Other team members workload increases possibly causing delays.	Clear scheduled tasks, remote work, periodical working meetings.
The implementation does not provide feasible results	Low	Medium	Model must be adjusted or changed entirely. Worst case severity is starting over.	Iterative model implementation using validation data, using existing literature and algorithms.
Poor communication between parties	Low	Medium	Confusion about the tasks, lack of feedback from the client, slows down project progression.	Active discussion, periodical working meetings.
Model not robust: Hardware, data or slight changes to the model affecting solutions/solving times	Medium	High	Model does not provide optimal or good enough solutions consistently.	Iterative model implementation, simplifying model if necessary.
The final model does not satisfy customer requirements	Low	High	The project objective is not reached.	Constant communication with Posti and presentation of intermediate steps and results at steering meetings.

Table 1: Updated risks of the project